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Applications of Nanotechnology: A Review

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Abstract: *Nanotechnology is referred to as the science of nanoscale which is objects that range in nanometers in size. Our efficiency to make bigger structures with nanometric accuracy is increasing rapidly and consists of reductive approaches and additive approaches. Nature, on the contrary, has mastered a pool of biological mechanisms that functions at the nanometric level.Structures which typically are self-assembled driven by the molecular chemistry of subunit operations. In the review, we describepresent-day developmentsin fabricating nanoparticles and biological assembly, and the effect they have on our world.*

1. Introduction

Nanotechnology can be the possible solution to the problems which are related to humans having to do with the vital needs and wishes for sustainable living. The vital needs of humans are food, water, energy, clothes, shelter, health and clean surrounding conditions. The wishes for lavish life include understanding and achieving computerization in each and every field such as space travel, increasing life expectancy. Due to continuous efforts of scientists and engineers during the last thirty years, there is substantial progress in different sectors such as agro, food technology, water purification, automobile, energy storage, cosmetics, cloth and fabrics, construction material, etc. Nanotechnology involves R&Don the atomic, molecular or supramolecular levels in the range of approximately 1-100 nanometres to give us a fundamental and basic understanding of phenomenon and composition. The nanometre-scale can be compared to the billionth part of a meter. In analogy, a human hair is in the range of 10,000 nanometres in diameter. Nanotechnology is used to create structures, devices and systems that have enhanced properties and functions because of their decreased size. The matter shows unusual physical and chemical properties due to the increase in surface areato volume ratio as particles get smaller in size & this is called quantum size effect. This means the bulk properties of materials at the nanoscale can be very different from those at a larger scale. Taking advantage of these characteristics of the material, scientist designs and produces devices by tweaking the shape and size at the nanoscale with wide-range of implications which could include medicine, electronics, military applications, computing, space science and many more.

1.1. History

The concept of nanotechnology first came into existence from a talk given by physicist Richard Feynman titled “There’s Plenty of Room at the Bottom,” at an American Physical Society meeting at Caltech on December 29, 1959, who pictured that the entire Encyclopedia Britannica could be printed in the head of a pin. The term “nanotechnology” was defined by Tokyo Science University Professor Norio Taniguchi in a 1974 paper as follows: “‘Nanotechnology’ mainly consists of the processing of, separation, consolidation, and deformation of materials by one atom or by one molecule.” Even though scientists have been working with nanoparticles for many years, most of the research work done was restricted by their inability to see nanoparticles itself. Hence, long before STMs and atomic force microscopes were invented Feynman pitched this revolutionary idea to his colleagues.

As determined in his quote (above), he chose to end with a “final question" that wasn't fully realized until the ’80s and ’90s. Finally,then, it was during these two decades, when the term "nanotechnology" was coined and researchers, starting with Eric Drexler, built up this field from the bedrock that Feynman made in 1959. But, some researchers such as Chris Toumeyneglect the gravity of Feynman in the formation of the intellectual breakthrough for nanotechnology.

Nevertheless, though the ultimate effect of Feynman's talk is debatable, it is certain that this work directly impacted Drexler's research.

1.2. APPROACH

We classify the production methods into two broad groups:

- The Top-down Approach: This approach signifies that the nanostructures are produced by cutting out crystal planes (removing crystal planes) which are already present on the substrate.
- The Bottom-Up Approach: This approach signifies that the nanostructures are produced onto the substrate by piling atoms onto each other, which give rise to crystal planes, which further pile onto each other, which results in the production of nanostructures.

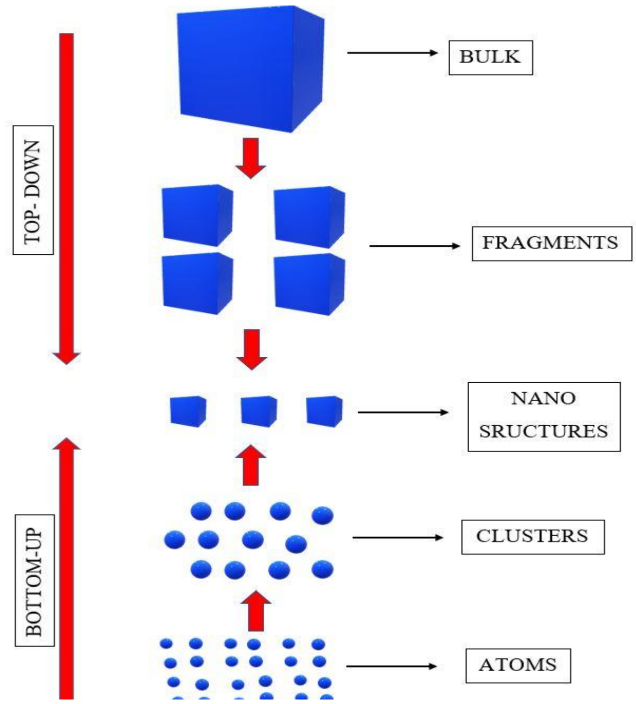

Fig1. *Top-down and Bottoms-Up Approach*

2. MATERIALS AND METHODS

2.1. FABRICATION METHODS

Firstly various methods used for fabrication are shown below in Fig. 2.

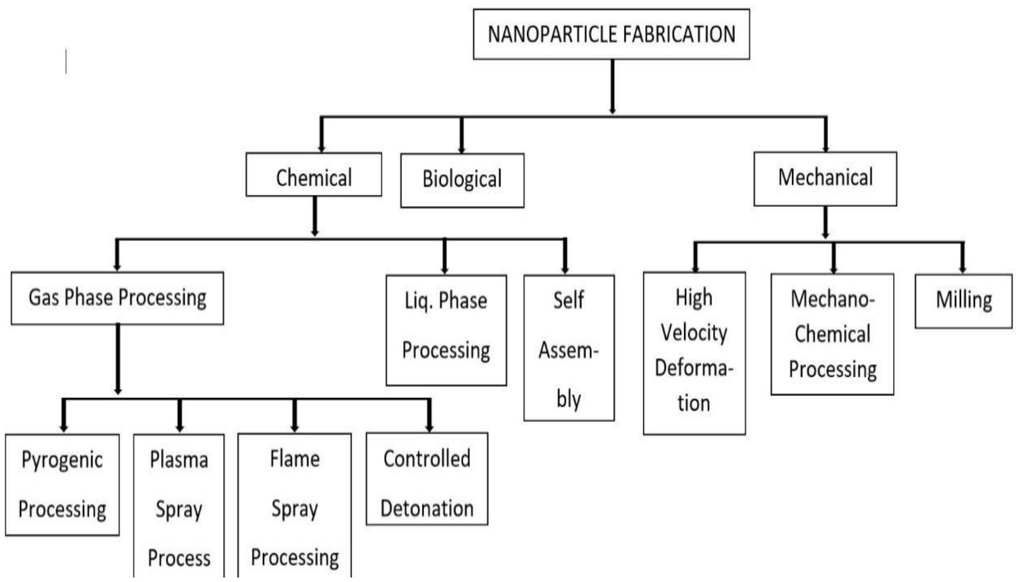

Fig2. *Fabrication of Nanomaterials*

2.2. Types of Nano Materials

Based on the dimension, Nanomaterials can be classified as Zero dimensional, one dimensional, two dimensional, three-dimensional nanomaterials.

Based on the materials Nanoparticles and Nanoscale materials can be classified into 4 types:

(i)Carbon-based nanomaterials: Based on the type these Nanomaterials contain carbon and are seen in structures such as tubes, ellipsoids or spheres.Carbon-based nanomaterials include fullerenes, CNT, graphene and its derivatives, graphene oxide, nano-diamonds, and carbon-based quantum dots. Graphene is the most researched nanomaterial in the recent decade; the fabrication methods of graphene are Liquid phase Exfoliation, Chemical Vapour Deposition, CNT unzipping, Epitaxial growth on SiC. Other C-based NMs are produced mainly by Arc discharge, CVD, and Laser ablation.

(ii)Inorganic-based nanomaterials: Generally they are metal and metal oxide nanoparticles and nanoscale materials.Inorganic-based nanomaterials include Metal NMs (Gold nanoparticles), quantum dots, Superparamagnetic Iron Oxide NPs, Paramagnetic Lanthanide Ions. Synthesis methods include-Precipitation, Template-assisted spinning, electrospinning, sol-gel techniques and CVD.

(iii) Organic-based nanomaterials: This type includes Nanoparticles that are mostly made of organic matter, excluding carbon-based or inorganic-based Nanoparticles. Organic nanomaterials include Dendrimers, Micelles, Liposomes, Ferritin. Most of the organic nanomaterials are naturally present while some are produced by chemical methods.

(iv)Composite-based nanomaterials:Composite based NMs are multiform structures where 1 phase on the nano-level which will either combine Nanoparticles with other Nanoparticles which are attached to larger materials or more complex frameworkNanocomposites can be divided into four types; (a) Ceramic-matrix nanocomposites including one component of metal and other component either nitrides, borides, silicides. (b) Metal-matrix nanocomposites which majorly includes CNT metal-matrix nanocomposites. (c) Polymer-matrix nanocomposites. (d) Magnetic nanocomposites

2.3. Applications

Nanotechnology has become the talk of the scientific community from the time it bloomed in the 2000s. Nanotechnology has found various daily life and industrial applications already and many major applications are yet in research and development It is not wrong to say that Nanotechnology has taken the technological world by storm. Of all the applications discussed all over the world, here are the major fields in which nanotechnology is being used and the ones in R&D.

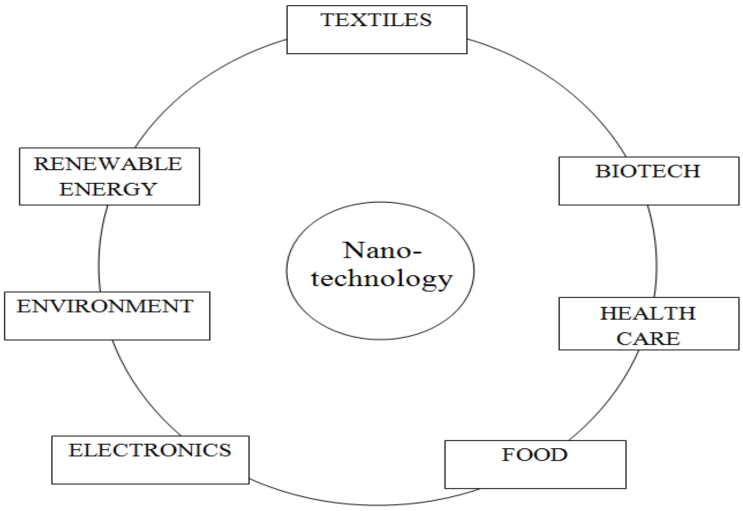

Fig3. *Various fields affected by Nanotechnology*

2.4. Nanotechnology in Electronics

Nanoelectronics is the subsequent step in electrical world. Nanoelectronics can be characterized as the incorporation on nanotechnology in electrical equipment This term includes an assortment of compounds, materials and devices which are similar in only 1 way that is they are small in size (nano-metric specifically), hence their quantum-mech abilities and inter-atomic synergy has to be researched in detail. Most of these materials embody hybrid molecular/semiconductor,1-D nanotubes/nanowires (e.g. Silver nanowires/CNT's) or advanced molecular engineering

Nano-electronics finds it's used in:

- Graphene Transistors
- High-density storage devices
- Quantum Computers
- Single Electron Transistor
- CNT based Nanosensors
- OLED display

2.5. Graphene Field Effect Transistor

Graphene field-effect transistors modify the standard FET by adding a graphene sheet around < 10 microns size amidst the source and drain. Since graphene is present which is just a compound of carbon just 1 atom thick, the channels have extraordinary sensitivity which has various uses such as in photo-sensing, magnetic mixing and biosensing.

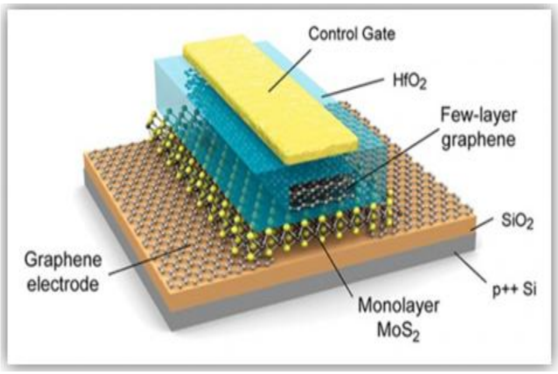

Fig4. *Schematic of Graphene Field Effect Transistor*

When employed in environmental sensors, this channel is often exposed to allow binding and detection of receptor molecules like aldohexose, cytochrome, haemoglobin, cholesterin, or peroxide onto the surface. once these molecules bind to the graphene channel, this alters the physical phenomenon and overall device response. Whereas the carbon in graphene usually is inert or does not bind with most materials, receptors like amino acids, antibodies or enzymes will be extra thorough sorption or a linker molecule connected to the channel surface. Molecules will then bond to those active sites through valency bonding, electricity forces or Van der Waals forces, transmission associate electronic transfer through the whole depth of the device.

Advantages of GFETs

- High-Frequency Operation.
- Work without much noise.
- Operate with little voltage.
- Consume little power.

2.6. Quantum Computing

In a quantum computing device, the distinction is that the tape exists during a quantum state, as will the read-write head. this implies that the symbols on the tape are often either zero or one or a superposition of 0 and 1. Quantum computers aren't restricted to 2 states; they cypher info as quantum bits, or qubits, which may exist in superposition. as a result of a quantum, pc will contain these multiple states at the same time, it's the potential to be immeasurable times a lot of powerful than today's most powerful supercomputers. Quantum computers conjointly utilize another facet of quantum physics called trap. If you cross-check a qubit in superposition to see its worth, the qubit can assume the worth of either zero or one, however not each (effectively turning your dapper quantum computer into a secular computer. Scientists got to devise ways that of constructing measurements indirectly to preserve the system's integrity. trap provides a possible answer.

Recent Advancements in the Field of Quantum Computers:

Computer scientists control the microscopic particles that act as qubits in quantum computers by using control devices.

- Ion traps use optical or magnetic fields (or a combination of both) to trap ions.
- Optical traps use light waves to trap and control particles.
- Quantum dots are made of semiconductor material and are used to contain and manipulate electrons.

2.7. Quantum Computers

There are five experimental necessities for building a quantum pc.

- The first demand is that the ability to represent quantum data robustly. as a result of a qubit maybe an easy two-level system, a physical qubit system can have a finite set of accessible states. Some examples are the spin states of a spin 1/2 particle, the bottom states associate degree first excited states of an atom, and therefore the vertical and horizontal polarization of one gauge boson.
- Second, a quantum pc needs the power to line a fiducial initial state. this can be a significant drawback for many physical quantum systems thanks to the imperfect isolation from their setting and therefore the difficulty of manufacturing desired input states with high fidelity.
- Third, a quantum pc needs long decoherence times, for much longer than the gate operation time. Decoherence is that the coupling between the qubit and its setting, which ends during a loss of the quantum part coherence. When decoherence, the quantum mechanical property related to coherence (e.g., superposition, entanglement) will not be discovered.
- The fourth demand is that the capability of mensuration output results from specific qubits. The result from a quantum rule is, in general, a quantum superposition. Therefore, it's necessary to browse out the results of the quantum state victimization the classical system with high fidelity.
- The fifth demand issues the power to construct a universal set of quantum gates. almost like a classical pc, a quantum pc has universal gates, that implement any legitimate quantum computation.
- Many implementations for a quantum pc are planned. One in all the well-researched implementations may be a nuclear resonance (NMR) primarily based quantum personal computer. during this manner, this experimental quantum pc solves a retardant by dominant nuclear spins victimization proton magnetic resonance techniques and retrieves the results perceptive the ensembled average of some property of the nuclear spins within the bottle.

2.8. Carbon-Based Nanosensors

The majority of nanosensors supported CNTs are applied within the field of biotechnology, with bio-assays and medical speciality as primary fields of application. The term bionanosensor/nano biosensor derives from the first principle of binding/immobilizing biological fragments on the surface or within the hollow cavity of CNTs. The hollow cavity of CNTs provides a with chemicals inert setting, and it's conjointly a possible active site of magnetic/electromagnetic response for novel bionanosensor technologies and nanoreactors through magnetism or electrical impulses. The CNTs structures functionalize the bionanosensor in detection the molecule of interest via binding to their surfaces. The multi-walled carbon nanotubes (MWCNTs), also as single-walled carbon nanotubes (SWCNTs), are applicable in nanosensor devices, but recent findings show that SWCNTs, having one layer of carbon, will simply transfer a chemical signal when the attachment of the interest object to their changed surfaces. The detection happens usually at intervals a timeframe of sixty s, and also the sensory structure will be simply reactivated for re-use. The sensory unit will be devised during a closed chamber, wherever the SWCNTs matrix is directly applied between electrodes on semiconductive skinny films. This arrangement of SWCNTs transmits the electrical impulse. the electrical physical phenomenon is altered consequently with the binding state of the CNTs, either certain or nonbound to the compounds of interest.

2.9. Applications of Cnt Based Nanosensors

- Biomedical Industry: There are sure cases like polygenic disease, wherever regular tests by patients themselves are needed to live and management the sugar level within the body. Children and senior patients might not be ready to perform this take a look at properly. CNT-based nanosensors have the benefits that they're thousands of times smaller than even MEMS sensors and consume less power.

- Automotive Industry: They're used to acquire info regarding vehicle parameters like pressure, vehicle altitudes, flow, temperature, heat, humidity, speed and acceleration, exhaust gas, and engine knock and force. Apart from enabling new fascinating options, CNT-based sensors are merely substitution recent technologies with cheaper and a lot of reliable devices.
- Manufacturing Industry: CNT based mostly chemical element gas device is employed in hydrogen observation and management for oil transformation, welding, rocket engines, and fuel cells. Recent analysis shows that raw SWNTs and metal changed SWNT skinny films are smart sensing materials for chemical element sense.

3. NANOTECHNOLOGY IN BIOTECH

Nanotechnology in biotech or Nanobiotechnology is that the application of nanotechnologies in biological fields. Researchers in the field of Chemistry, Physics and Biology considers nanotech as a part of their studies, and joint ventures within which they every contribute equally are not scarce. While biotechnology deals with metabolic and different physiological processes of biological specimens as well as microorganisms, together with applied science, nanobiotechnology will play a decisive role in developing and achieving several helpful tools within the study of life

Advantages of Nanobiotechnology

The pathophysiological conditions and anatomical changes of morbid or inflamed tissues will probably trigger lots of scopes for the event of varied targeted nanotechnological merchandise. This development is wished to be fruitful in the following ways:

- Drug targeting is achieved by taking advantage of the distinct pathophysiological options of morbid tissues.
- Several nanoproducts can be accumulated at higher concentrations than traditional medicine.
- Increased vascular porosity let alone impaired lymphatic drainage in tumours improves the impact of the nanosystems within the tumours or inflamed tissues through higher transmission and retention.
- Nanoparticles are effectively wont to deliver/transport relevant medicine to the brain overcoming the presence of the barrier (meninges).
- Nanosystems have the capacity of selective localization in inflamed tissues.

Various areas of Research Include

- Applications of nanobiotechnology in medical and clinical fields
- Nanomechanical Oscillator
- Nanobots

3.1. Applications of Nanobiotechnology in Clinical Fields

Diagnostic applications: Current diagnostic ways for many diseases depend upon the manifestation of visible symptoms before medical professionals will acknowledge that the patient suffers from a selected sickness. However, by the time those symptoms have appeared, treatment could have an attenuate probability of being effective. so the sooner an unwellness may be detected, the higher the prospect for a cure is.

- Detection: Nanobiotech offers an answer by employing semiconductor nanocrystals (also observed as "quantum dots"). These minuscule probes will stand up to considerably a lot of cycles of excitations and photon emissions than typical organic molecules, that which promptly decompose.
- Nanotechnology as a tool in imaging: intracellular imaging will be made attainable through the identification of target molecules with quantum dots (QDs) or artificial chomophores, like fluorescent lipids which will facilitate direct investigation of intracellular signalling advanced by optical techniques.
- Individual target probes: Nanogold particles integrated with short segments of deoxyribonucleic acid form the idea of the easy-to-read takes a look at for the presence of any given genetic

sequence. If the sequence of interest within the samples, it binds to c-DNA tentacles on numerous nanospheres and forms a cluster of visible gold balls.

- Sparse cell detection: Sparse cells are each rare and physiologically distinct from their encompassing cells in traditional physiological conditions (e.g. cancer cells, lymphocytes, craniate cells and HIV-infected T cells). Scientists developed nano-systems capable of effectively sorting thin cells from blood and alternative tissues.

3.2. Nano-Mechanical Oscillator

A nano-scale cantilevered beam can be used to detect the presence of viruses and bacteria and find their masses. The beam can be coated with antibodies specific to a particular virus and then put into a substance to attract that virus. The oscillation of the beam can then be measured and compared to the oscillation before exposure to the substance.

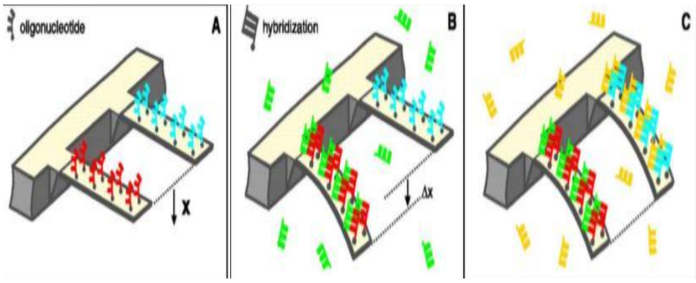

Fig5: *Bending of cantilevers detected by an optical deflection technique.*

3.3. Nanobots

Nanobots are robots that are microscopic in nature, measured mostly on the dimensions of nanometers. they're presently within the analysis and development part, however, on realization they're expected to try and do specific tasks at the atomic, molecular and cellular level and facilitate in conveyance concerning several breakthroughs, particularly in bioscience. Nanobots are called nanomachines, nanorobots, nanomites, nanites or nanoids.

Potential Applications of Nanobots:

- Distinguishing and destroying cancer cells a lot of accurately and effectively. •
- Making nanoparticles that roll upbound tissues and so scanning the body with a magnetic resonance imaging (MRI) may facilitate highlight issues like polygenic disorder.
- These sensors may monitor our blood chemistry, inform us that there is some disturbance in the system, discover spoiled food or inflammation within the body, and more.
- With close to limitless customizable sensing properties, nanorobotics would unlock new sensing capabilities we will integrate into our systems to watch and live the globe around us.
- A team out of Caltech developed a replacement variety of material, created from nanoscale struts crisscross just like the struts of a small tower, that's one amongst the strongest and lightest.
- In near future Nanobots could connect to a neural interface which will help us to control them and program them to form various formations.

4. NANOTECHNOLOGY IN MEDICINE

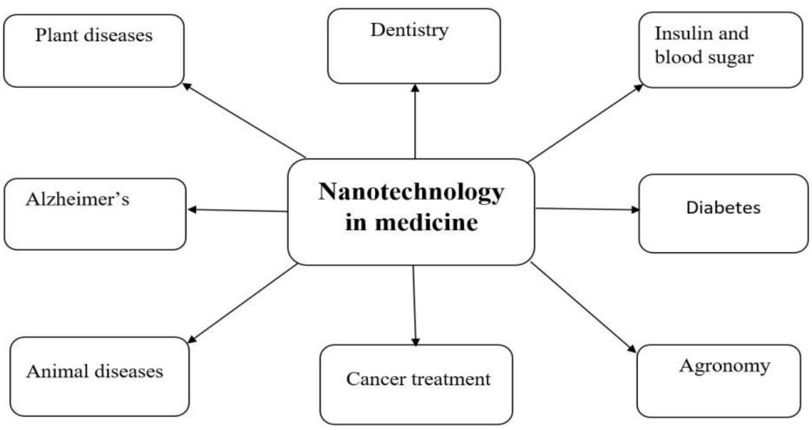

Fig6: *Medical cases in which Nanotechnology is used.*

4.1. Cancer Nanotechnology

As with any cancer treatment, the key issue is to achieve the required concentration of the therapeutic agent in growth sites, thereby destroying cancerous cells whereas minimizing injury to ancient cells. Throughout this regard, several ligand-targeted therapeutic ways unit of measurement being developed to beat the problems associated with normal medical care medication, thereby providing any tools among the arsenal of cancer medical aid.

Although these conjugated agents have shown promising power compared with normal medical care medication, limitations in their delivery remains a significant downside.

Tools of nano-engineering for cancer medical aid:

The tools of nanoengineering with applications in early cancer detection and treatment embody the following:

- Liposomes: Liposomes became versatile tools in biology, chemistry and medicines thanks to their vast diversity of structure and compositions. samples of liposome-mediated drug delivery unit of measurement antibiotic and daunorubicin, that unit of measurement presently being marketed as cyst delivery systems. resin glycol (PEG)ylated liposomal antibiotic immunoliposomes carrying expression plasmids of sequence secret writing amino alkanoic acid hydroxylase, and promising results were obtained during a} very rat model for Parkinson’s malady.
- Polymeric micelles: A particle is outlined as a set of amphiphilic surfactants molecules; micelles are arising to be a keystone within the way forward for a medical speciality. Antitumor antibody-conjugated compound micelles, encapsulating the water-insoluble drug Taxol, effectively acknowledge and bind to varied cancer cells in vitro.
- Dendrimers: Dendrimers are organic compound compounds that comprise of a series of branches around the associate inner core, the dimensions and form of which might be altered as desired. It is a pretty modality for drug delivery. in a very recent work, DNA-assembled polyamidoamine dendrimer clusters were ready for cancer-cell-specific targeting. The distinctive design of dendrimers allows multivalent attachment of imaging probes. It will be conjointly used as an extremely economical diagnostic tool for cancer imaging
- Nanocantilever: Microarray strategies that use the detection of specific biomolecular interactions have currently become an essential tool for sickness designation, ordination analysis and drug discovery. small bars are anchored at one finish which might be built to bind to molecules related to cancer. These molecules can even bind to altered polymer proteins that are a gift in sure forms of cancer. throughout detection procedures, once biospecific interactions occur between a receptor immobilized on one aspect of a cantilever and a substance in answer, the cantilever bends; if detected optically, it's doable to inform whether or not cancer molecules are a gift.
- Carbon nanotubes: Another kind of nanodevice for biomarker detection is nanotube. Carbon nanotubes are merely carbon cylinders composed of aromatic hydrocarbon rings that are applied in biology as sensors for detective work desoxyribonucleic acid and supermolecule. they're conjointly used as diagnostic devices for the discrimination of various proteins from bodily fluid samples and as carriers to deliver drug, immunogen or supermolecule..
- Quantum dots: Quantum dots (QDs) are semiconductor nanoparticles that glow a selected colour when being lit by lightweight. the colour they glow depends on the dimensions of the nanoparticle. once the quantum dots are lit by actinic ray light, a number of the electrons receive enough energy to interrupt free from the atoms. This ability permits the QDs to manoeuvrearound the nanoparticle, which creates an electrical phenomenon band during which electrons are unengaged to move through a piece of fabric and conduct electricity.

4.2. Use of Technology in the Treatment of Diabetes

Diabetes is one amongst the foremost diseases of recent civilization. it's termed as a chronic illness that happens once exocrine gland doesn't manufacture enough hypoglycaemic agent or when the body is unable to use the insulin already created. the foremost common treatment to combat polygenic disease is that a hypoglycaemic agent is directly introduced into the blood of the patient exploitation injections. The treatment of polygenic disease is often achieved by technology within the following ways:

- Development of oral hypoglycaemic agent: Insulin is created by an exocrine gland that is employed to control the aldohexose levels within the body. The oral route is taken into account to be one amongst the foremost appropriate and cosy ways for the treatment of polygenic disease. Chitosan nanoparticles (CS NPs) are crammed with a hypoglycaemic agent that enhance the enteral absorption of supermolecule molecules to an excellent extent.
- Artificial exocrine gland(Pancreas): The original plan of development of artificial exocrine gland was 1st represented in 1974. Its construct is simple: a device conductor measures the amount of aldohexose in blood repeatedly; this info feeds into alittle interface that calculates the desired amount and this required amount of hypoglycaemic agent enters the bloodstream from a small reservoir. differently to revive aldohexose level is that the use of a small silicon box containing duct gland cells taken from animals. The box is encircled by a fabric with an awfully specific nanopore size (about twenty nanometres in diameter).
- The Nano-pump: The nanopump may be a powerful device that has many applications in drugs. one amongst the main applications of the pump is delivery of a hypoglycaemic agent into the blood. The pump injects a hypoglycaemic agent into the patient's body at a rate that balances the quantity of sugar within the patient's blood. The pump has the flexibility to administer little drug doses over an extended amount of your time.

4.3. Nanotechnology Used in the Detection of Insulin and Blood Glucose

Another vital use of nanotechnology is to quickly live minute amounts of endocrine and blood glucose level to judge the health of the body's insulin-producing cells. It may be earned inthe following ways:

- By Micro-physiometer: Micro-physiometer is associate degree instrument wont to live dynamics of phenomena on an awfully little scale i.e. micrometre. The micro-physiometer is constructed from electrically conductive carbon nanotubesHowever, the new device detects endocrine levels unceasingly by activity the number of electrons transferred once insulin molecules get modify within the presence of aldohexose. once the cells turn out a lot of endocrine molecules, this within the device will increase and contrariwise, permitting observation endocrine concentrations in real-time.
- By sensors: One of the effective strategies wont to monitor endocrine and blood glucose level is of victimization synthetic resin glycol beads coated with fluorescent molecules. during this methodology, the beads are injected underneath the skin that keeps within the ECF. once aldohexose within the ECF drops to dangerous levels, aldohexose displaces the fluorescent molecules and creates a glow. device microchips also are being developed to unceasingly monitor key body parameters together with pulse, temperature and blood sugar. A chip would be planted underneath the skin and transmit a sign that might be monitored unceasingly.

4.4. Nanotechnology in Food

Nanotechnology is becoming popular in numerous fields like electronics, robotics, medicine, etc. However, it has been less famous within the food sector as compared to other fields. Most important applications in this sector are food processing, food packaging, food preservation, food quality monitoring etc. Many varieties of sensors are designed to detect the presence of pathogens, leakage, presence of gases, discolouration, change in pH, odour or temperature.

- Food Processing: Food processing is the formation of food products from raw ingredient using suitable operations. Processing of food includes various steps-removal of toxic substances, protection from pathogens, preservation of food, increasing the shelf life, improving the colour, texture, odour of foods etc. Nowadays, all these processes are made more effective by using nanotechnology.
- Antimicrobial Packaging: Barriers are made of nano-sized particles to inhibit microbial growth up to a certain level which may lead to food spoiling. Generally, nanoparticles in such kind of packaging are made of silver. Silver nanoparticles have the ability to inhibit and control the development of bacteria. Compounds like zinc oxide have antimicrobial nature which proves to be a vital factor in nanotechnology. Titanium dioxide can be used as a coating material in packing material to prevent the growth of bacteria.

- Smart Packaging: The incorporation of sensors into food packaging technology has resulted in what is called ‘smart or intelligent packaging. Sensors are devices which detect the physical quantity of compounds and convert them into signals. They are used to regulate the internal environment of food, their properties are detected and indicated regularly by nanosensors. The environment of food is regularly sensed for oxygen content, temperature, pathogens etc. Nanosensors also help to estimate the shelf life of products. Some examples include gold nanoparticle fused enzymes for detection of microbes.
- Nutritional Supplements ¬ The total market value of nanofood in every sector of food technology makes a heavy profit to the economy of a country. The commercial name for such nanofood supplements is “Nanoceuticals”. Nanopowders are nano substances which increase absorption of essential components like nutrients, vitamins, minerals, etc. Thus, nanotechnology in food supplements is very effective because they act more effectively in the human body due to the smaller size.
- Food Quality Monitoring: Nanosensors are materials of nano-size used mainly for the detection of pathogens or contaminants in food. Nanosensors have very high sensitivity. The advantage of nanosensor system is that thousands of nanoparticles are often placed on one sensor for accurate detection of the presence of pathogens inside stored grain bulk in bins and may be arranged and distributed into the gaps of grain bulk.
- Pathogen Identification in Food: Quality of food is monitored by using several methods. One such method is the detection of a pathogen like E. coli in a very food sample. it's done by measuring the quantity of sunshine scattered by the mitochondria of the cell using an advanced spectrometer. This binding will end in a scattering of a nanosized light which might further be detected by analysis of digital images. Over the past decade, development of absorption indicator biosensor particles attached to anti- Salmonella bodies on a silicon or a gold nanorod arrangement has taken place within the field of nanotechnology.

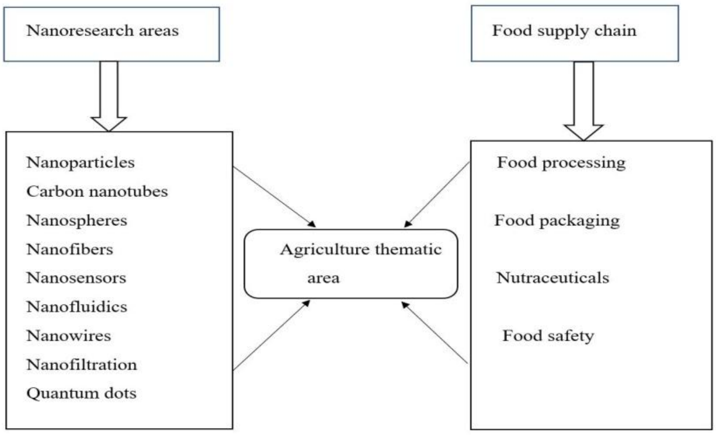

Fig7: *Agricultural Thematic Area Table*

Improved Food Storage: Many times, stored food undergoes problems like change in odour, discolouration, change in texture, rancidity and alter in flavour occur because of the presence of oxygen in food products. This results in oxidation of fats, oils and growth of microorganisms within the food components. to beat this issue, oxygen-absorbing sachets are used which act as reducing ingress of all the gases, including oxygen and therefore the exit of moisture. Thus, they prevent the spoilage of food.

5. NANOTECHNOLOGY IN ENVIRONMENTAL SECTOR

Green nanotechnology refers to the employment of nanotechnology to boost the environmental property of processes manufacturing negative externalities. It conjointly refers to the employment of the product of engineering to boost property. It includes creating inexperienced nano-products and using nano-products in support of property. Inexperienced engineering has been delineating because the development of unpolluted technology, "to minimize potential environmental and human health risks related to the manufacture and use of engineering product, and to encourage replacement of the existing product with new nano-products that are a lot of environmentally friendly throughout their lifecycle.”

Furthermore, nanotechnology can be accustomed to improve renewable energy sources; as an example wind, energy potency can be improved by integrating light-weight, additional strength nano-materials for rotor blades. In biomass energy integrating nano-based preciseness farming to optimize crop accustomed to manufacture biofuels. Nano-coatings can be used to forestall the corrosion in recurrent event energy equipment, whereas nanocomposites are utilised to form drilling machines in geo-energy additionally fatigue-resistance.

5.1. Solar Energy

A novel electric cell style that combined the best geometry of a nanowire-based solar cell with the idea of exploitation environmentally friendly, cheap and sturdy conductive PV parts is being researched. This electric cell consisted of vertically orientated n-type flowers of zinc nanowires, encircled by a movie created from p-type metal chemical compound nanoparticles. It's incontestable associate potency improvement of up to 5% in star thermal collectors by utilizing nanofluids as an absorption mechanism. The results showed that the employment of a vertically aligned nanowire array eliminated the matter of exciton diffusion versus light absorption by permitting the sunshine to be absorbed within the vertical direction whereas allowing exciton extraction in the orthogonal direction. reportable experimental results on star collectors supported nanofluids made up of a range of nanoparticles like carbon nanotubes, graphite and silver.

But, presently TiO2-based cells were terribly inefficient with incident photon-to-current efficiencies of (10%) or less (at the bandgap energy) and peak energy conversion efficiencies of (0.6%) or less over the entire star spectrum.

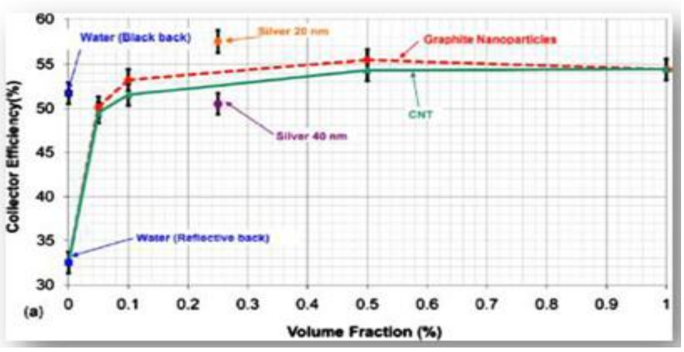

Fig8: *Experimental microsolar thermal collector efficiency as a function of nanoparticle volume fraction*

To summarize it is reported that the visible radiation photocurrent can be increased by coating TiO2 nanowires with gold or silver nanoparticles. The improvement was achieved thanks to optical scattering from the plasmonic nanoparticles, that multiplied the effective optical path of the skinny film. Platina and graphite coated electrodes were ready bypulse current lepton deposition and soot staining technique to be used as counter electrodes.

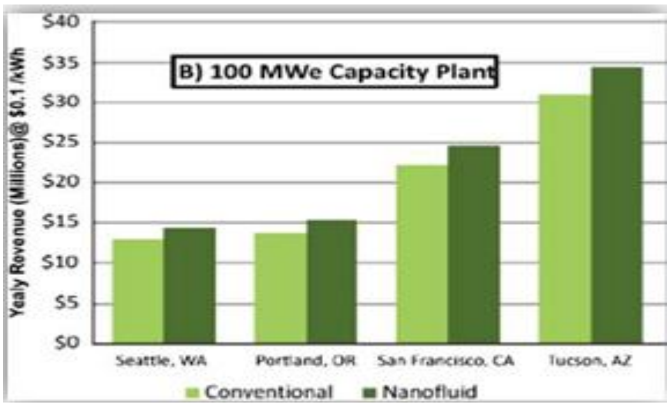

Fig9: *Comparison of the estimated revenues for a (100 MWe) commercial-scale plant by using a conventional and nanofluid receivers*

A comparison is made (by using an optimized nanofluid receiver regarding 5% a lot of economical than a standard one) in financial terms forward sale of electricity at ten cents/kW h and scales it up to a hundred MWe, commercial-sized plant. The figure explained that this sort of improvement adds nearly $3.5 million to the yearly revenue of an outsized solar energy plant. using nano-structured layers in skinny film solar cells offered 3 necessary advantages:

- Due to multiple reflections, the effective optical path for absorption was much larger than the particular film thickness light-generated electrons and holes ought to travel over a way shorter path and therefore recombination losses were greatly reduced. As a result, the absorbent layer thickness in the nano-structured cell can be as skinny as (150 nm) rather than many micrometres within the ancient thin-film solar cells.
- The energy band gap of assorted layers can be created to the required style price by variable the dimensions of nanoparticles. This allowed for a lot of design flexibility within the absorbent of solar cells.

5.2. Fuel Cell

Nanotechnology may well be used as a strong tool for economy production of H from solar power in a very clean, environmentally friendly and cheap means by using water cacophonous by photocatalysis. The background of photo-catalytic H production was conjointly given. We reviewed the recent development of exploitation nanostructured materials used for photocatalytic H production. The technology was gap a replacement aspect within the development of extremely active, nanostructured photo catalysts with massive surface areas for optimized lightweight absorption, reduced distances (or times) for charge carrier transport and any favourable properties. It was terminated that photocatalytic H production offered distinctive opportunities to develop an alternate and property energy system and to scale back the emission of greenhouse gases.

- CNTs) demonstrated good potential as multifunctional materials in improving (PEFCs) performance.
- (CNTs) are often inserted into the components of fuel cells to boost its performance and reduce its cost.
- (CNTs) had high strength and toughness to weight characteristics, which encouraged manufactures to use them as reinforcing fillers to boost the mechanical strength of (PEFCs).
- (CNTs) are often utilized in electrocatalyst supports because of their high area and thermal conductivity. Also, they'll be applied in gas diffusion layers because of their high electrical conductivity.

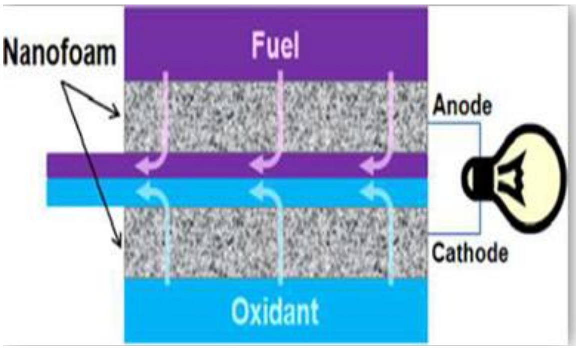

Fig10: *Nanofluidic Cell*

A nanofluidic cell which utilized fluid flow through nanoporous media is shown here. The concept of nanofluidics applied to membrane-less, miniaturized fuel cells compatible with standard micromachining methods and on-chip integration. It is concluded that their prototype demonstrated higher area, reduced activation over-potential, faster kinetic characteristics and moderately enhanced cell performance within the high cell voltage regime with up to 14% higher power density.

Therefore, this nanofluidic cell had high overall efficiency, low-cost and miniaturized power sources.

5.3. Wind Energy

The implementation of nanotechnology into wind energy applications is bringing together different methodologies and techniques to handle more effectively a number of the good challenges facing the science of wind engineering. the foremost critical a part of this accomplishment is to stimulate a harmonious integration of scientific and technological endeavours for the following generation of turbine models.

The main scope of nanoscale technology is to boost the sturdiness of the critical energy system components and stabilize their performance during generation, transportation and distribution with the lower maintenance cost still as, with significantly fewer gas (GHG) emissions to the atmosphere. additionally, to it, the innovative nanomaterials and nanosensors might be wont to lend assistance for the renewable energy smart grids integration and energy production decentralization.

Weight Saving

To increase the electrical power produced by a turbine, blades must grow long, since the facility captured by a wind machine is proportional to the square of blade length. At the identical time, blades must be kept as tight as possible.

Nanocomposite materials with excellent strength-to-weight and stiffness-to-weight ratios are now getting used to facilitate the event of next-generation high-performance blades. Nanoparticles are wont to equip other materials with new properties so as to attain novel functions. The synthesis of those multifunctional nanocomposites involves the employment of low relative molecular mass polymers (di- acetylenes) which generally have long-term stability and excellent processability. They even have good diffusion barrier properties and exceptional water repellency.

Advantages:

- Tensile strength of up to 40%.
- Tensile modulus upto 68%.
- Flexural strength of upto 60%.
- Flexural Modulus >126%.
- Distortion temperature from 65% TO 152%.

Positive Impact on Environment

With the assistance of nanotechnology, water quality may be improved. a number of the nanomaterials which will be used for correction of water are carbon nanotubes (CNTs), zeolites, nanoparticles of zero-valent iron (ZVI), silver nanoparticles, etc. alternative nanomaterials like philosopher's wool (ZnO), titanic oxide (TiO2), wolfram chemical compound, function a photocatalyst. These photocatalysts will oxidize organic pollutants into harmless materials. TiO2 is that the most most well-liked material because it has high photostability, high photoconduction, simply offered, cheap and non-toxic. Silver nanoparticles have an antimicrobial result. Also, several compound nanoparticles are getting used for sewer water treatment.

Another new technology is understood as nanofiltration which might be utilized in water treatment in homes, offices, and industries. Mo disulphide nonporous membrane is employed for energy economical chemical action of water that filters 5 times over the standard ones. to scrub oil spills within the water bodies, a nanofabric towel has been developed that is woven from little wires of metal-metal chemical compound which will absorb oil 20 times its weight.

6. NANOTECHNOLOGY IN INDUSTRIAL SECTOR

Nanotechnology is impacting the sphere of products, several merchandises that incorporate nanomaterials are already throughout a kind of items; many of that people don't even notice contain nanoparticles, merchandise with novel functions ranging from easy-to-clean to scratch-resistant. samples of that automotive bumpers are created a lighter, commodity may be a ton of stain repellant, the ointment may be a ton of radiation-resistant, artificial bones are stronger, phone screens are lighter weight, glass packaging for drinks land up during an extended shelf-life, and balls for various sports are created heaps of durable. victimization nanotech, at intervals the mid-term fashionable textiles will become "smart", through embedded "wearable electronics", such novel merchandise have to boot a promising potential notably at intervals the sphere of cosmetics, and has varied potential applications in serious business.

6.1. Nanotechnology In Textile Field

The use of technology at intervals the textile trade has increased chop-chop due to its distinctive and valuable properties. there's considerable potential for profitable applications of technology in cotton and various textile industries. Its application can increase the economical properties of textile method and merchandise. The use of tech. permits textiles to be capable of multiple functions and switch out materials with special uses, similarly as medication, ultraviolet protection, easy-clean, water and stain repellent and anti-odour. The long-standing time success of tech in textile applications is in areas where new principles are combined into durable, different functions whereas not changing the inherent textile properties, similarly as accessibility, plasticity etc.

Properties of nano textile fibres

- Water repellence: The water-resistant property of fabric created by nano-whiskers, that are hydrocarbons and 1/1000 of the dimensions of a typical cotton fibre, once mixed with the fabric it produce a peach fuzz result while not lowering the strength of cotton. The areas between the whiskers on the fabric are smaller than the everyday drop of water, however still larger than water molecules; water therefore, remains on the very best of the whiskers and higher than the surface of the fabric. However, liquid will still tolerate the fabric, if pressure is applied to it). Nanosphere impregnation involving a three-dimensional surface structure with gel forming additives that repel water and forestall dirt particles from attaching themselves are used.
- UV-protection: Inorganic UV blockers are more preferable to organic UV blockers as they're non-toxic and chemically stable under exposure to both high temperatures and UV. Inorganic UV blockers are usually certain semiconductor oxides like TiO_2, ZnO, SiO_2 and Al_2O_3. Among these semiconductor oxides, titanium oxide (TiO_2) and philosopher's wool (ZnO) are commonly used. it absolutely was determined that nano-sized titanium oxide and philosopher's wool are more efficient at absorbing and scattering UV radiation than the traditional size.
- Antistatic: An antistatic agent could be a compound used for the treatment of materials or their surfaces so as to scale back or eliminate the buildup of electricity generally caused by the triboelectric effect. The molecules of an antistatic agent often have both hydrophilic and hydrophobic areas, almost like those of a surfactant; the hydrophobic side interacts with the surface of the fabric, while the hydrophilic side interacts with the air moisture and binds the water molecules.
- Antimicrobial: Although many antimicrobial agents are already in used for textile, the most important classes of antimicrobial for textile include organo-silicones, organo-metallics, phenols and quaternary ammonium salts. The bis- phenolic compounds exhibit a broad spectrum of antimicrobial activity. For imparting antibacterial properties, nano-sized silver, titanium oxide,zinc oxide, triclosan and chitosan are used.
- Wrinkle resistance: To impart wrinkle resistance to fabric, the resin is usually utilized in conventional methods. However, there are limitations to applying the resin, including a decrease within the strength of fibre, abrasion resistance, water absorbency and dye-ability, still as breathability. to beat the constraints of using resin, some researchers employed nano-titanium dioxide and nano-silica to enhance the wrinkle resistance of cotton and silk respectively. Nano-titanium oxide utilized with acid as a catalyst beneath actinic ray irradiation to catalyses the cross-linking reaction between the polysaccharide molecule and additionally the acid.

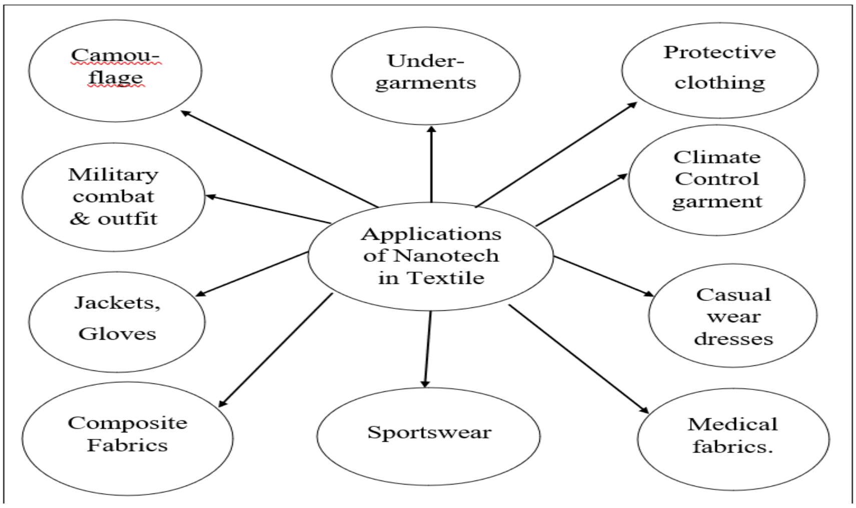

Fig11: *Applications of Nanotech in Textile Industry*

6.2. Nanotechnology in Construction Industry

In step with associate economic assessment, engineering science options a big effect on the construction sector. Many applications are refined for this selected area to increase the sturdiness and increased performance of construction elements, energy potency and safety of the structures facilitating the convenience of maintenance and to provide multiplied living comfort.

Though the self-cleaning feature has been attainable to appreciate using micro-sized coverings and on the surface treatments e.g. Teflon, polysiloxane containing coatings, etc. currently this feature has become a selling tool/motto for engineering science applications, particularly for client markets like construction, textile, etc.

Nanoparticles of TiO_2, Al_2O_3 or ZnO are activated as the last coating on construction ceramics to bring this profile to the surfaces. TiO_2 is obtaining used for its capability to interrupt down dirt or pollution once exposed to ultraviolet illumination then permit it to be washed off by rain on materials like tiles, glass and sanitary ware.

Advantages

- The incorporation of nanoparticles, CNTs and nanofibers to extend the strength and strength of building material composites in addition as for reduction in pollution
- Production of low-cost corrosion-free steel.
- Production of thermal insulating materials with a performance ten timescurrent business choices.
- Production of coats and skinny films with the self-cleaning ability and self-colour modification to attenuate energy usage.
- Production of nano-sensors and materials with the ability to sense and self-healing ability.

Uses of Nano-Particles in Construction:

- Even a comparison of the pursuance of carbon nanotubes, a technology product with spider silk, one comprehends how the natural mechanism is well optimized. CNTs were first found in Russia in 1962 and then were later found in Japan. These materials possess a permanency a hundred times over steel however as a draw backside, they're extraordinarily pricey (20–1000 euros/g). One high impact application at intervals the sphere of energy consumption relates to the event of nanomaterials with terribly high insulation performance, like aerogel. This material was developed by NASA at intervals the Nineteen Fifties and has been said as ‘‘solid smoke”. it's composed of air (99.8%) and silicon dioxide nanoparticles (0.2%) having the lowest thermal conduction of any solid (between zero.004 and 0.03 W/mK
- Using nanotech to a stronger understanding of cement association merchandise Concrete is that the foremost used construction material on Planet Earth and presents ensuing porosity that permits water and alternative aggressive components to enter, leading to permeation and chloride ion attack, resulting in corrosion issues. Therefore, the nanoscale study of the association merchandise (CASAH, calcium hydrate, ettringite, monosulfate, unhydrated particles and air voids), as a type to beat sturdiness problems, may well be an important step in the concrete property. Investigations throughout this field have already been distributed in recent years.
- Employing nanoparticles to boost the firmness and stability of building material composites.The same authors state that that development isn't owing to the pozzolanic reaction, as a result of calcium hydrate consumption was low, however, instead, to the multiplied of silicon dioxide compounds that contribute to a denser microstructure. in step with an architect, the use of nano-silica on sludge/fly ash mortars, compensate the negative effects associated with sludge incorporation in terms of setting time and initial strength.

7. CONCLUSION

Nanotechnology has opened doors of technology for us which we did not even know were there. Nan biotechnology continues to be in its early stages. Nanotech has the abilityto affect our food systems and the systems which control our agriculture. Food security, unwellness treatment delivery ways, new tools for molecular and cellular biology, new materials for infective agent detection, and protection of the setting are samples of the vital links of engineering science to the science and engineering of agriculture and food systems.

The present review has given further evidence to this issue and it has tried to address what all the potential environmental impacts of the technology might be. Although the uses of nanotechnology in each and every field is endless and still in its infancy stage, we need a set of laws which will govern the way nanotech will be used further in future.

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