OVERVIEW OF NANOMATERIALS

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Article History: Received: 12.12.2022 **Revised:** 29.01.2023 **Accepted:** 15.03.2023

Abstract

Nanomaterials are quickly becoming recognised as the most potent substance in the universe. Due to the fact that it has a strong foundation in the "Nanotechnology". Aerogel, fullerene, and carbon nanotube are three distinct nano materials that are discussed in detail here, and their applications range from tissue engineering and cancer medicines to sports equipment and lithium-ion batteries to solar panels. The impact of nano materials on human existence is greatly expanding daily. People should therefore be aware of the significance of nanotechnology and nano materials. The content covered in the current study spans "Green nanotechnology" to the beginnings of nanotechnology. Additionally, it examines contemporary developments in nanotechnology. The general information about nanotechnology and nano materials is well-equipped, allowing people to understand the topic with ease.

Keywords: Universe, nanotechnology, tissue engineering, nano materials.

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DOI: 10.31838/ecb/2023.12.1.104

1. Introduction

Research in this field, as well as nanotechnology, is gaining popularity daily. The next millennium will see a technological revolution brought on by the developing fields of nano science and nanotechnology. Possible long-term effects of nanotechnology on our way of life. The impacts of nanotechnology will be felt across the board, from consumer products and electronics to computers and IT to biotechnology and beyond, to aerospace defense and cleaner, greener healthcare. Efforts to accelerate nanotechnology development are supported by government and industry in the United States, Europe, Australia, and Japan. The word "nano" refers to a billionth. A nanometer is one billionth of a metre (10^{-9} metres). A nano material is about 100 nm in size. It is a bulk material if it is larger than 100 nm. A nano material can have a radius of 1 nm or 50 nm. Most compounds have atoms with radii smaller than one nanometer. Approximately 25 atoms make up a cluster with a 1 nm radius.

Unbelievable facts include the following:

i) A human hair has a diameter of 75000 nm.

ii) Hydrogen atoms have a diameter of 0.1 nm and a [1] of 1. Its nucleus is just 0.00001 nm in size.

Background

When compared to bigger materials and tiny atomic or molecular structures, nanoparticles provide a bridge of tremendous scientific interest. Nanotechnology is a state-of-the-art methodology established quite lately for use in scientific study. Richard Feynman, an American physicist, gave a presentation titled "There's Plenty of Room at the Bottom" on December 29, 1959, at a meeting of the American Physical Society held at Cal tech. This lecture is sometimes credited as inspiring the development of nanotechnology [2]

In 1974 [3], Norio Taniguchi, a Japanese physicist at Tokyo University of Science, first used the term "Nano-technology." At the conference, he gave the examples of thin film deposition and ion beam milling, two semiconductor processes that can be controlled at the nanoscale scale.

According to his understanding of nanotechnology, these effects may be achieved by altering a material at the atomic or molecular level in areas like processing, separation, and consolidation. It wasn't until 1982 that the term "nanotechnology" was once again stressed, even though the first study on the topic was published in 1981 by Eric Drexler, who was unaware of Taniguchi's contributions. [4]. [5][6].

Molecular Nanotechnology is a field that K. Eric Drexler pioneered and popularized with his article. He spoke out for the relevance of nanoscale phenomena in engineering. This kind of nanotechnology, as envisioned by Drexler, is hence often referred to as "Molecular Nanotechnology" (M.N.T.) or "Molecular Manufacturing" [7].

Nanomaterials

Phrase associated with nanotechnology is "nano material." Because it complies with all nanotechnology principles. Materials classified as a group of substances with at least one dimension less than or equal to about 100 nm are those made from blocks of nanoparticles. In the universe, a single nano material is so tiny that it cannot be seen with the human eye. To examine them, we always need a powerful electron microscope.

The International Organization for Standardization defines nanoscale materials as having "approximately" between 1 nm and 100 nm in size [8]. This includes materials with nanoscale exterior dimensions as well as those with nanoscale interior structures.

A particle-containing substance meets European Commission standards if at least 50% of its particles have one or more external diameters between 1 and 100 nm. A lower barrier (between 1% and 50%) for the distribution of feasible number sizes may be created [9] in circumstances when worries about the environment, human health, safety, or competitiveness are needed.

Aerogel

The first Aerogel was made in 1931 by "Samuel Stephens Kistler" [10]. It is made up of nanometer-sized particles that are covalently bound to one another.

Composite paper non-woven paper is made by soaking carbon fibers in resorcinol-formaldehyde aerogel and pyrolyzing them. They allow air through due to their high porosity. The density of carbon aerogels determines whether they may be utilized as electrodes for de-ionization devices or capacitors. In addition to their employment in super capacitors, their huge surface area makes them a useful material in other applications [11].

Fullerene

The 60-carbon molecule "Fullerene" or "Buckyball" was discovered in 1985 by R. F. Curl, H. Kroto, and R. E. Smalley, who evaporated graphite using a laser beam (C60). Its chemical structure is a closed cage with 20 hexagons of 6 carbon atoms and 12 pentagons of 5, giving it the appearance of a soccer ball.Buckyball clusters, nanotubes, mega tubes, polymers, nano-onions, and other variations of fullerene exist. In the sphere of medicine, fullerene has uses for the gradual release of medications in the treatment of cancer in small doses [12].

Carbon nanotube

In 1991, Japanese electron microscopist Sumio Iijima found carbon nanotubes on the cathode during fullerene arc-evaporation. [13].

A tubular shape is achieved by rolling the graphite sheet. Carbon atom lattice-based molecular tubes with nano structures that are both cylindrical and on the nanometer scale. In recent years, three unique types of nanotubes have emerged:

a) The hexagons on this armchair nanotube are arranged in a row that is perpendicular to the nano tube's axis.

b) A zigzag nanotube is characterized by a single row of carbon atoms along its center.

c) Nanotubes that have a twist or spiral around them are called chiral nanotubes.

As a result of the discovery that some nanotubes are found within others, single-walled nanotubes (S.W.N.T.) and multi-walled nanotubes (M.W.N.T.) are two types of carbon nanotubes (M.W.N.T.) Single-walled nanotubes (SWNTs) have one cylinder, whereas multi-walled nanotubes (MWNTs) have multiple. Almost all cylinders have a diameter of 1 nm [14, 15]. Arc discharge, chemical vapour deposition, and laser ablation are the typical processes used to make carbon nano tubes.

Steel is at least 100 times weaker than carbon nano tubes. Additionally, they perform better than copper at conducting heat and electricity. Potassium atoms have been included into carbon nano tubes to further improve their electrical conductivity.

Properties

Nanoparticles have several interesting characteristics, each of which is size-dependent. Characteristics of macro-scale materials can be well described by classical mechanics, but nanoscale particle properties remain a mystery. Properties of the nanoparticles must therefore be explained using quantum mechanical techniques.

Optical: The colour of the nanoparticles and the bulk materials differ. For instance, gold seems bright red in colour but appears yellow in quantity.

Electrical:Consider a flat, conducting plate that is both broad and thin, with great length and width. Assume that a plate's thickness is measured in nanometer. An electron will be constrained along one dimension yet be free to move along the other two in this scenario. This phenomenon is referred to as a "Quantum well."

Take into consideration a conducting wire that is both lengthy and thin in diameter. Here the electron has complete freedom of motion along its length but is constrained along its two orthogonal axes. We call this set-up a "Quantum wire" for short.

Magnetic: While nano-sized ferromagnetic particles do not exhibit hysteresis when exposed to alternating magnetic fields, bulk ferromagnetic materials do.

Structural: Despite having the same crystal structure as the bulk material, it was shown that nanoparticles had their own unique lattice features.

Mechanical: The mechanical properties of a material, such as its hardness, elasticity, and ductility, are all determined by the nature of the bonds between its constituent atoms. Changes in these properties result from imperfections in the crystal structure or the presence of impurities. To put it another way, carbon nanotubes are 20 times as strong as steel [16] and can withstand a lot of wear and tear.

Applications

These nanoparticles seem to be everywhere. Nanomaterials may be ubiquitous in the natural world. As an additional note, considering how often we use nanoparticles, it's reasonable to believe that life would be challenging without them. Would you say that's what you're trying to convey? Certainly, this is the case. This is because nanotechnology is now being used in almost every industry, from engineering to medicine to space travel to sports. Automobile bumpers, metal-cutting tools, car catalytic converters, stain-resistant clothes, coats, suits, spectacles, anti-corrosion paints and coatings, a wide variety of textiles, cosmetics, and dyes, and many more may include nano materials.

Tissue Engineering

Tissue engineering requires new biomaterials to control tissue growth as well as new monitoring and evaluation techniques for manufactured tissues. Carbon nanotubes are the most significant substance for tissue engineering. It's useful for things like delivering transfection agents, keeping tabs on the local microenvironment, tracking individual cells, and serving as a scaffold that can be integrated into the host organism. In order to better assess tissue development, carbon nanotubes may be used as contrast agents in optical, magnetic resonance, and radio tracers. Monitoring and modifying intracellular and inter cellular activities would be helpful for creating high-quality artificial tissues [17].

Medical

Cancer is a deadly disease that is currently affecting all populated places. Therefore, by performing drug delivery at a specific organ within the human body, nano materials can aid in the treatment of cancer.

It is crucial if therapeutic molecules are to reach their full potential. Due to the high level of toxicity and potential for major side effects associated with cancer chemotherapy, these needs are more crucial in this situation. In the recent years, a wide range of drug delivery technologies, including nano systems, polymer conjugation, and micro-systems, have been improved. As a result, medication delivery using nanoparticles is safe [18].

Tennis

Nanomaterials have also made an influence in the world of sports.In the modern world, tennis is growing more and more popular. Manufacturer "Babolat" introduced the "V.S. Nanotube Power Racquet" in 2002. Graphite with carbon nanotube infusion was used to make the racquet. The racquet was built with nano materials, which made it lighter and more durable than steel. In the meantime, Wilson, a tennis ball maker, created the "Double Core tennis ball." On the inner core, it bears a covering of clay nanoparticles. Air that can't easily escape the ball works as a sealant thanks to this clay.

Spectacles and Sunglasses

People wear spectacles or sunglasses to protect their sensitive eyes from sunshine and airborne debris. Numerous glasses contain titanium oxide or zinc oxide nanoparticles. These nano materials shield the eyes of those wearing glasses from sunlight. The spectacles consequently seem red, green, or blue [1].

Electronics

The use of nanotechnology is growing in the electronics industry as well.

It has several electrical applications [16], including as in storage devices, circuit boards, field effect transistors, LEDs, and more.

Energy

Both solar cells and rechargeable batteries, which are used to store energy, are composed of nano materials. Rechargeable lithium batteries are an essential part of new hybrid vehicles. The use of renewable energy sources to recharge electronic devices such as laptops, cell phones, and tablets is critical [19].

Automobiles

Nanomaterials have a lot more uses in automotive engineering. They can be found in dashboards, paintwork, coatings, wheels, bumpers, and automotive body frames.Nanotubes are utilised in cars to store hydrogen fuel, reducing hazardous emissions as a result.

Space

The exterior body of spacecraft, as well as lightweight spacesuits and jackets, are made of aerogel.

Environmental

Sensors based on nanoparticles are used to identify water and air pollutants. Using nano material catalysts, toxic emissions from vehicles and businesses can be changed into less damaging gases.

Cosmetics

Sunscreen creams contain zinc oxide and titanium oxide nanoparticles. Hair creams and dyes use nanoparticle-based colours and dyes [16].

Nanotechnology developments

Nanomaterials will be utilized to generate quicker and more efficient semiconductor devices, disease-targeting treatment approaches, aerospace structural materials, high-energy density rechargeable batteries, energy-efficient catalysts, enhanced low-cost solar cells, commercially viable fuel cells, etc.

Procedures Using Nano devices in Neurological Surgery

In order to perform cellular and sub-cellular surgical procedures, it has been proposed to employ novel micro-instrumentation with nanoscale characteristics. Similar to neuritis, carbon nano structures exhibit remarkable mechanical, electrical, and conduction capabilities at the nanoscale. So, they're put to work stimulating nerve cells and reconnecting two ends of a severed nerve. Changing the MWNTs' surface charges via chemical functionalization affects how they work in the brain. Neurons may activate the phospholipase C signaling pathway when exposed to nerve growth factor, according to one idea.

Chip Fabrication

Mirrors will be used in extreme ultraviolet lithography to focus light with a 13 nm wavelength in order to print features at a 32 nm size. Chips made on a smaller scale will operate considerably more quickly.

Aerospace Materials

Using materials that are one hundred times stronger than current ones might have several benefits. Products made using these materials have the potential to be one-hundred times more efficient and one-hundred times lighter than their traditional equivalents. This factor might be raised to about 250 with the use of a diamond composite material. Energy consumption may be drastically reduced in lightweight vehicles like cars, trucks, trains, planes, and spacecraft if their surfaces were automatically smoothed to lessen losses from internal friction and air resistance. The usage of nanotechnology-related items can significantly lower the cost of space transportation.

Nanoguitar

Through the use of technology, it is designed for amusement. The tiniest guitar in the world has six strings that are each approximately 50 nano meters (or 100 atoms) wide and is 10 micro metres long, or roughly the size of a single cell [1].

Sustainable nanotechnology

When used to operations that have unfavorable consequences on the environment, nanotechnology is considered "green." It also refers to using nanotechnology-related products to improve sustainability. Producing environmentally friendly nano products and using nanotechnology into environmental safeguards are essential components of sustainable operations.

Toxic-free nano materials and nano products are produced at low temperatures using less energy and renewable inputs wherever feasible via the application of life cycle thinking applied to all stages of the design and engineering process, which is at the heart of green nanotechnology. The ultimate goal [22] of the project is to create nano materials and commodities without hurting people or the environment. Solving environmental issues is a primary motivation for the nanotechnology industry.

For nano materials and goods made from them to be produced with little environmental impact, green nanotechnology must first demonstrate that it can be integrated into the current production infrastructure. Green manufacturing technique is the term used to define this kind of production.

The creation of goods that either directly or indirectly improve the environment is the second objective of green nanotechnology. Directly cleaning desalinated water, hazardous waste, treating pollutants, or sensing and monitoring environmental contaminants are all possible with nano materials or goods. Fuel can be indirectly saved by using lightweight nano composites in autos and other forms of transportation. Additionally, many cleaning chemicals needed in routine maintenance procedures are eliminated by self-cleaning nanoscale surface coatings [23].

2. Conclusion

The term "general purpose technology" is frequently used to describe nanotechnology. The application of nanotechnology is continuously altering commonplace things, making them widely available, reasonably priced, and very durable. The advancements in aircraft materials brought about by nanotechnology will make space travel and colonisation safe and economical. Nanomaterials will significantly alter societal norms and human behaviour.As a result, nano materials are shaping the course of human history and the future of the planet.

Nanomaterials will have a huge impact on the engineering field and the manufacturing sector as the next industrial revolution, enabling the development and production of high-quality goods with innovative features at extremely cheap costs and through greatly enhanced means of production.

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