An overview of nanotechnology and its application

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Abstract. Numerous advantages of nanotechnology depend on its capacity to modify materials at incredibly small scales to attain certain features that would significantly improve the materials science toolset. Considering the molecules and interacting groups of molecules in connection to the bulk macroscopic qualities of the material becomes necessary when controlling the underlying molecular structure, which provides control over the macroscopic chemical and physical properties. Physiological and medical applications necessitate both materials apparatus with a high degree of specificity to communicate with the body on a molecular (or subcellular) level. This may result in specialized clinical uses for cells and tissues that aim to acquire the most therapeutic results possible while limiting negative effects. The applications and main scientific and technological facets of nanotechnology are explained in this overview, along with some of its potential medical uses

Keywords: Nanotechnology, application Risk, Toxicity, Remediation, Nanoparticles

1. Introduction

Nanotechnology has been employed in industries for different industrial applications and grow exponentially over 5 decades [1]. It has a great significant impact on medical equipment like imaging probes, drug delivery systems, and diagnostic biosensors in the pharmaceutical communities of practice. According to Morris [2] nanotechnology is the application of knowledge and control over matter at dimensions between 1 and 100 nm, where special physical features enable the development of novel applications. Hobson [3] said Nanotechnology, is the advancement of man-made or designed particles with dimensions in the nanoscale range (1-100nm). A field of expertise deals with objects and materials with nanoscale structures. Said that due to its advancements in computing, networking, and data

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processing, nanotechnology has become a major force for electronic gadgets [4]. Nanotechnology has created better power densities to maintain the storage charge that is employed for various battery types with reduced inflammable possibilities, and conversion of waste heat in nano-machine to useful energy. More so, solar film solar panels are being built by scientists that can be mounted to machines cases and lightweight piezo-electric nano-wires to produce usable energy from wind, friction, and body heat to operate mobile electronic equipment [5-6]. Nanoscale and sensors can help to deliver cost-efficient structural control of roads, bridges, trains, parking structures, and flooring over time. In the medical field, nanotechnology is being studied to improve injuries to the spinal cord or brain cells, or nerve cells. Berthiaume, et al. [7] said nanotechnology has vastly been investigated due to its potential to increase the field of biotechnology and medical advances although, regulatory agencies such as the FDA oversees the emerging field of nanotechnology using legislative arrangements. According to Matthew [8] nanotechnology creates multidimensional impacts on societies as the benefits are manifested daily. Avinash and Mahendra [9] narrate the significance of nanotechnology in science and environmental clean-up of long-term challenges such as hazardous waste sites. Nanotechnology is simply the science of miniature particles. McNeil [10] stated that Nanotechnology is an area of interest where new products are modeled at the atomic and molecular regions. As scientists take advantage of atomic and molecular assemblages that are constructed at the nanoscale, nanotechnology has emerged as one of the emergent scientific initiatives of the early 21st century. This acts as the rationale behind the design of nanoparticles and their usage in diagnostic

2. Nanotechnology and its applications

Recognition of nanotechnology as a transforming skill that tends to stimulate scientific innovation while greatly benefiting society. Applications of nanotechnology are reflected in the medical field, computing, engineering, etc.

2.1 Applications of nanotechnology in electronics

Kumar et al. [11] studied the development of various signal transduction techniques using nanomaterials in the realm of biological and chemical analyses changing biosensors, and enabling in vivo research. Results from nanotechnology-based research on microbial identification have been extremely exciting and encouraging. This is accorded to their high surface permeability, surface-to-volume ratio, reactivity, and high penetrability, Nanomaterials use less substrate and material than larger materials and perform physical and chemical processes more effectively [12]. Nanotechnology has significantly improved computing and electronics by providing faster, smaller, and more portable systems that can manage and store larger amounts of information. Applications of nanotechnology include the followings: Nanoparticles copper suspension have been developed as a safer, cheaper, and more reliable alternative to lead base solder and other hazardous materials commonly used to fuse electronics in the assembling process, Enhancement in computer booting performance, and also to improve data saving during a system shutdown, Ultra high definition displays which production of ultra-responsive hearing aids, flash memory for smartphones, and more bright colors using quantum dots while using less energy and thumb drives. Pandey [12,] mentions that when nanotechnology began to take center stage in research initiatives in both wealthy and developing nations of the world, it raised concerns among scientists about the function that it plays in electrical gadgets. The field of nanoelectronics, which was created by fusing nanotechnology and electronics, is concerned with handling, characterizing, building, and producing electronic devices at the nanoscale.

The electrical characteristics of materials change as they are shrunk, and interatomic interactions and quantum phenomena assume a key role. To employ them in next-generation electronic devices, it is necessary to understand their electrical characteristics at the nanoscale. The age of nanoelectronics has begun as a result of the desire to reduce the size and increase component density.

2.2 Applications of Nanotechnology in Medical and Healthcare

Sahoo et al. [13] mentioned that the use of nanotechnology in medicine and physiology involves materials and tools with a high degree of specificity for subcellular (i.e., molecular) interactions with the body. Bhattacharyya et al [14] said that Nanomedicine, which may be described as the molecular-level monitoring, maintenance, building, and management of human biological systems utilizing designed nanodevices and nanostructures, is only one step removed from nanotechnology. It may also be seen as an additional use of nanotechnology in the realm of diagnostics and medical sciences. The appropriate distribution of medications and other therapeutic agents throughout the patient's body is one of the most crucial challenges. The creation of pharmaceuticals is anticipated to be one of nanotechnology's most significant therapeutic applications shortly. Already, there are a staggering number of new applications [13, 14]. These applications either make use of the special characteristics of nanoparticles as pharmaceuticals or drug-related substances on their own or are created for novel methods of controlled release, drug targeting, and recovery of medications with limited bioavailability. Nanoscale polymer capsules, for instance, may be created to disintegrate and release medications by predetermined charges as well as to permit separate releases in specific conditions, such as a corrosive environment, to encourage the absorption of a tumor as opposed to healthy tissues. The development of nanomedicine is currently extending medical tools, knowledge, and remedies. To provide precise solutions for illness prevention, diagnosis, and therapy, the application of nanotechnology in medicine draws on the natural scale of biological phenomena. Some of the medical improvements made possible by nanotechnology include better imaging and diagnostic tools made possible by nanotechnology to increase the effectiveness of treatments. Determining the cause of atherosclerosis, or the buildup of plaque in arteries, and treating it and creating regenerative medicine, which involves the creation of bone and brain tissue.

2.2.1 Drug delivery technique

According to Bhattacharyya et al [14], a particular class of nanostructure called dendrimers may be precisely created and used for a wide range of purposes, including the treatment of cancer and other disorders. Dendrimers carrying various materials on their branches can perform multiple tasks at once, including the identification of diseased cells, the diagnosis of disease states, cell death, the delivery of drugs, the reporting of locations, and the reporting of therapeutic outcomes. Suri et al [15] mention that the use of nanoparticles in drug delivery measures less than 100 nm of biodegradable substances, including natural or manufactured polymers, lipids, metals, or both. Since bigger macromolecules are less effectively absorbed by cells than nanoparticles, they could be used as efficient delivery and transport systems. Drugs can either be affixed to the particle surface or integrated into the particle matrix for therapeutic uses. The fate of a drug, after it enters the biological environment, ought to be under the control of a drug-targeting system. Numerous studies have been conducted on nanosystems with various biological characteristics and compositions for applications in medication and gene delivery. Park [16] when it comes to targeted drug administration to tumors, the use of nanotechnology in medicine delivery resulted in the tiny particles may have distinct features equally in vivo and in vitro. Numerous nanoparticle formulations have been created and successfully evaluated in small animal models, but there hasn't been much success in translating the small animal outcomes to human clinical settings. Reexamining the significance of nanotechnology in medication delivery, comprehending the constraints of nanoparticles, identifying the widespread misconceptions in the sector, and accepting uncomfortable facts are necessary for successful translation. By concentrating on the relevant topics, like boosting their ability to load drugs, affinities for target cells, and spatiotemporal regulation medication release, nanoparticle techniques can significantly improve drug delivery.

2.3 Applications of nanotechnology in energy

Nanotechnology is enhancing alternative energy sources and utilizing existing energy sources to help the world's expanding energy demands. [17]. The following are examples of how nanotechnology is used in the energy sector: Increased fuel production efficiency from petroleum-based raw materials thanks to improved catalysis Through improved combustion and less friction, this has helped to reduce fuel consumption in cars and power plants, Manufacturing membranes, and scrubbers made of carbon nanotubes to remove carbon dioxide from power plant exhaust, Using cheaper to produce and simpler to install nanostructured solar cells to convert sunlight into electricity, The use of carbon nanotubes to create longer, stronger, and lighter windmill blades and the creation of flexible piezoelectric nanowires that can be weaved into garments and thin film solar electric panels that can be mounted on computer boxes [18]. The exploration of alternative sustainable energy is a focus of active research and development. These resources are in addition to the ones that currently power human society, such as petroleum, coal, hydraulic power, natural gas, wind power, and nuclear plants. The energy that can be extracted from these alternative sources is still primarily used for small-scale powering applications, even though there is potential for their use in the large-scale supply of power [19]. For many years to come, the development and use of energy transmission systems may be impacted by nanoparticles and nanomanufacturing techniques. For instance, nanotechnologies might use fuels for transportation more effectively, perhaps reducing the increase in demand for liquid fuels used for long-distance travel. The dimensions required for installing and maintaining electrical transmission lines and pipelines may be reduced by the strength and volume reduction of construction materials derived from nanoparticles compared to current materials [20]. The production, storage, and use of energy all have the potential to have a large negative influence on the environment, with a focus on the energy sector. Even though we are still far from having a sustainable energy system, scientists are looking at ways to advance energy nanotechnologies. Energy is one of the top 10 issues of the EU's Seventh Framework Programme (FP7). The research will therefore concentrate on hastening the development of affordable solutions for a more sustainable energy economy. Consider the qualitative development of energy state for residential and automobile applications by the twenty-first century [21]. One of the most recent nanoscale innovations that can serve as a suitable successor for the quantum-dot cellular automata used in CMOS technology. The QCA technique produces circuits with desirable characteristics including little power usage, fast speed, and compactness. In memory structures, these characteristics might be clearer. CMOS technology-implemented circuits include drawbacks like high power consumption, huge physical size, and high leakage current [22]. Nanotechnology is progressively offering various novel techniques, particularly energy-based cancer therapeutics, to address issues of systemic toxicity associated with chemotherapy and improve treatment resolution. A few of the ongoing studies in this rapidly expanding field include improvements to therapy targeting, and the capacity to facilitate combined medicines and treatment imaging. Cryoablation, high-intensity focused ultrasound (HIFU), microwaves, radio frequency (RF), photodynamic, and alternating magnetic field (AMF) therapies are some prospective focal areas in energy-based therapy research, each having its benefits and drawbacks. The limited destruction of diseased tissue with a reduced risk of adverse effects such as systemic toxicity or infection makes these techniques preferable to systemic therapies or surgical resection. Additionally, these techniques are researched mostly as outpatient operations and are regarded as minimally invasive. By inducing a local temperature excursion inside the intended treatment area, energy-based therapies eliminate malignant cells [23]. The use of renewable energy sources for a cleaner and healthier environment has received more attention in recent years as nonrenewable sources of energy have been expanding quickly. Researchers have looked into a variety of options for producing sustainable energy from renewable sources for more than 20 years. Supercapacitors, batteries, wind turbines, solar cells, fuel cells, photo electrolysis, and wind turbines all have the potential to be effective ways to directly transform one state of energy into another. Numerous forms of nanotechnology and related byproducts have been included in these new energy systems to boost their efficacy. These new advancements, however, also pose several threats to the environment and human health [24]. Smaller than 100 nm components and appliances present new opportunities for energy capture, storage, and exchange. The sun produces a tremendous quantity of energy each day through the nuclear fusion process. Even the sun emits more energy in a single second than humanity has used in all of its history. It has been noticed that the technical potential of solar energy is vastly greater than the total primary energy required at the moment. This study has looked closely at the sun-harvesting technology that uses nanomaterials. The solar collector, fuel cell, photocatalysis, and solar photovoltaic systems have all incorporated nanomaterials to boost efficiency [25].

2.4 Application of Nanotechnology in Modern Textiles

Asif et al [26] mention that Nanotechnology is thought to be able to mechanically control the structure of materials comprehensively and affordably in addition to producing microscopic structures. Most significantly, one definition of nanotechnology is "atomic and molecular level activities with real-world applicability for people. The typical diameters of nanoparticles in commercially available products range from 1 to 100 nm. Without a doubt, the development of a new class of superior materials has been made possible by nanoscience and nanotechnology as well as the revival of material science, using nanoengineering and nanostructuring, such as textiles and polymers. [27] All areas of technology and science, including mechanics, computing, optical, healthcare, energies and aviation, polymers and textiles, material science, and materials processing technologies, are projected to be significantly impacted by the rapidly developing discipline of nanotechnology [28]. The performance of textiles is already being improved by this technology, which is attracting interest on a global scale despite its relative youth. An extended range of qualities is made possible by the unique use of nanotechnologies in textiles, with the possibility for new and enhanced uses in goods [29. The primary focus of the textile industry has been on finishing fabrics made of natural and synthetic fibers to provide desirable hand, surface texture, color, and other special aesthetic and practical features. The introduction of NT ten years ago sparked major advancements and improvements in this area of textile technology. [30] The finishing of fabrics has taken on new directions and shown considerable potential for substantial advancements with the use of NT. Customers now have a far wider selection of textile products in terms of both aesthetic and practical qualities every day. To ensure client satisfaction, new technology is being developed in a variety of technical textile applications. One of the most crucial fields that are now expanding significantly is nanotechnology [31]. Nowadays, new high-performance textiles kinds are created using various finishing, coating, or manufacturing processes to create fibers or fabrics. Additionally, finished clothing is treated with nanoparticles (10–9 m in size). Protective clothing, smart textiles, hygiene textiles, antiballistic or bulletproof vests, or functionally finished clothing like water-repellent or wrinkle-resistant clothing are all covered by these nanoengineered textiles [32]. The commercial multifunctional textile uses of nanotechnology are quite promising. Nanotechnology has quickly expanded in its use in textiles due to its distinctive properties. Fabric may easily contain nanomaterials, which can be created using a range of techniques, including physical, chemical, and biological ones. By using it, textile processes and products can be made more valuable and have better qualities at a reduced price [33]. Nanotechnology has the potential to make textiles multipurpose by enabling the development of materials with distinctive properties including antimicrobial, odor- and odor-repellent, flame- and UV-protective, water-repellent, and wrinkle-resistant [34]. The unique and useful characteristics of nanotechnology have led to a rapid expansion of its usage in the textile sector. Nanotechnology has a lot of potential for commercially successful uses in the cotton and other textile industries. Its use can economically increase the benefits and worth of textile products and processing [35]. Nanotechnology is employed in the creation of multifunctional textiles and materials with unique properties, such as odor- and water-repellent, UV protection, easy cleaning, and antibacterial. Future uses of nanotechnology in textiles will succeed if new ideas are incorporated into long-lasting, multifunctional textile systems without sacrificing the intrinsic characteristics of textiles, such as processability and flexibility [36]. The uses of nanotechnology in the textile sector are numerous and varied. Nanoparticles can be used to create textiles with special properties like durability, water resistance, wrinkle resistance, and high tensile strength by surface coating or surface changes. Nanotechnology can also be employed to overcome the drawbacks of conventional techniques that result in tensile strength loss, a reduction in abrasion resistance, functional loss, etc. Furthermore, nanotechnology offers less expensive and non-toxic alternatives to these conventional techniques [37]. Nanotechnology is increasingly being used in the textile industry because of its distinctive and desirable properties. In its wide range of applications, nanotechnology is also benefiting the textile sector. Nanotechnology offers a wide range of uses in the textile chemistry business, including the production of clothing with features like UV protection, wrinkle resistance, antibacterial properties, and stem resistance. Future textile applications of nanotechnology will succeed if novel concepts are incorporated into robust, multifunctional textile systems without sacrificing the intrinsic qualities of textiles [38. Industrial protective textiles are frequently used to shield employees from dangerous chemicals, high temperatures, flames, mildew, lead, dry particles, and damaging aerosols. Kevlar, Nomex, Tychem, and Tyvek fibers are the most often used materials in industrial protective textiles. Kevlar is used to make heat and abrasion-resistant clothing, including sleeves and gloves, as well as cut protection. Tyvek offers industrial workers, particularly those in the automotive, manufacturing, and pharmaceutical sectors, a blend of toughness, comfort, and protection [39]. To attain functional and high-performance qualities, the textile sector around the world is implementing more promising technologies, such as specialized coating, plasma-based goods, smart/technical technologies, and nanotechnologies. Nanotechnology has a significant potential to provide cutting-edge, innovative goods that might boost the economy and open up new markets for the global textile industry, thereby boosting national economies and addressing major social issues [40]. The principles of nanotechnology are based on the observation that when materials are shrunk to the nanoscale scale, their properties are radically altered. There are numerous ways to make nanotextiles. The unique and useful characteristics of nanotechnology have led to a rapid expansion of its usage in the textile sector [41]. Nanotechnology-based altered or improved characteristics can offer fresh or improved functionality. The interdisciplinary field of nanotechnology is expanding and is thought to be the start of a new industrial revolution. The regions where novel concepts will be incorporated into robust and multifunctional textile systems without compromising the inherent qualities are where nanotechnology in textile applications will succeed in the future. The development of nanotechnology has brought both great potential and difficulties to the textile sector, especially the cotton sector [42]. The textile industry has modernized thanks to the use of nanotechnology in smart textiles. Smart textiles were created using fabric touch pads, bulletproof jumpsuits, invisible coatings, and advanced fibers. Nanomaterials are utilized to create ICPs (inherently conductive polymers), also referred to as artificial muscles, which are used to mimic biological muscles. The most efficient antibacterial bandages or dressings are made of textiles coated with AgNPs (silver nanoparticles) [43]. Conductive inks used as pressure pads for encapsulation are impregnated with gold, nickel, and copper nanoparticles. Fabric switches and iPod controls made of carbon-doped polymers still have their piezoelectric capabilities. In textiles, woven optical fibers serve a variety of purposes, including deformation detection, light transmission, sensing, and data transmission. Another idea for transferring graphic and multicolored surfaces is light-emitting fabrics [44]. Despite being viewed as not being very inventive, the textile sector is among the economic areas where technological advancements are used regularly and on a larger scale. The most recent developments in the fields of nanotechnology, electronics, and biotechnology should be specifically noted here. Numerous scientific studies demonstrate how new technologies utilized in the textile sector have a demonstrable influence on the production of novel products with distinctive qualities and goods that are deserving of the moniker smart textile [45]. An extended range of qualities is made possible by the unique use of nanotechnologies in textiles, with the possibility for new and enhanced uses in goods. The commercial potential of nanotechnology for the textile sector is enormous. This is mostly because traditional techniques that are used to give textiles varied qualities frequently do not lead to long-lasting results and can cause the materials to lose their usefulness after repeated washing or wearing. As a result, advances in nanotechnology have created a vast array of options for textile finishing methods, leading to ground-breaking new finishes as well as novel application procedures. The primary focus is on using various types of nanoparticles or building structured surfaces based on nanotechnology to make chemical finishing more manageable, and robust, and dramatically increase its usefulness [46].

2.5 Application of Nanotechnology in Agriculture

Pramanik, et al. [47] mentioned that NT, or nanotechnology, has been highlighted as a viable using technology to revitalize the food and agricultural industries and improve the standard of living for the underprivileged. Nanotechnology has enormous potential applications in several industries, including health precaution, materials, textiles, info and communiqué knowledge, and energy. Particularly in the agricultural industry, nanotechnology is crucial for food processing, agricultural production, and packaging, water purification, food safety, as well as environmental cleanup as well as crop development, and plant defense. Through the use of site-specific medication and gene delivery systems, genetically enhanced plants and animals, and nanomaterials, agricultural output may be increased.

Table 1. Nanotechnology in the farming sector (Areas of application) Pramanik, et al. [47].

Area of application	Uses
Crop production	
products for protecting plants	For enhanced effectiveness and plant disease pest management, nanoparticles encapsulated insecticides, nanocapsules, and nanoemulsions are released under-regulated and cyclic conditions.
Nanofertilizers	nanocapsules, and nanoparticles from Buckyball fertilizer and viral capsids to improve the absorption of nutrients of plants and supply of nutrients at specified sites
Precision agriculture	Nanosensors linked to the Global GPS (Global Positioning System) navigation system precise application of fertilizer and pesticide, Real-time crop growth, and soil environment monitoring.
Soil improvement	
Water/liquid \retention	To store water and liquid agrochemicals in soil for their later delayed release to plants, nanomaterials like zeolites and nano clays are utilized.
purifying of water	
Cleanup of pollutants and water purification	Toxic compounds are filtered and bound by making use of nanomaterials as in carbon nanotubes (CNTs) and nZVI nano clays, which are then removed from the environment.
Diagnostic	
diagnostic tools and nanosensors	Nanostructures and nanomaterials, such as CNTs and nanofibers are electrochemically active very sensitive physiological sensors that are utilized to monitor circumstances in the environment, plant health, with growth.
livestock and fishing	Smart herds, fish pond cleaning technology, Buckyballs, nanoparticles, nanocapsules, dendrimers, medication administration, and nano-vaccines are all examples of nano veterinary medicine.
crop breeding	
genetic alteration of plants	Plant cells are given nanoparticles containing the desired DNA or RNA to undergo a genetic transformation or to activate a defensive mechanism that has been activated by pathogens.
plant-derived nanomaterials	

plant-derived nanomaterials	Nanofibers made from bio-nanocomposite, Wheat straw, soy hulls, and cotton waste are being produced to strengthen garments.
food sector	airtight applications of silicate nanoparticles food product nanosensors and packaging for pathogen and contaminant detection in sustenance

As shown in Table 1, nano fertilizers exhibit location-specific delivery, decreased toxicology, and improved nutrient utilization in addition to the controlled chemical release. In addition to improving solubility and soil dispersion, nanosized mineral micronutrient formulation can also reduce absorption and fixation, increase bioavailability, increase NUE, and conserve fertilizer resources.

2.6 Application of nanotechnology in wood-based products industries

Jasmani, et al. [48] examined that Utilizing nanotechnology could produce wood-based products that are more durable, versatile, and lightweight. An urgent demand to use sustainable and biodegradable nanosized materials has been created by growing environmental concerns. It is possible to safely and sustainably generate this novel substance known as nanocellulose from forest resources. Evans et al. [49] stated that there is an increased interest in converting cellulose to nanocellulose due to the quantity of lignocellulosic material from forests. Bi et al. [50] examined the nano cellulose and stated that Nanocellulose can be utilized as a substrate, stabilizing agent, or electrode for non-forest items such as electronics, sensors, batteries, food, pharmaceuticals, and cosmetics due to its adaptability [51]. The functionality of currently available wood-based products could be improved using nanomaterials. For instance, using Nanoparticles in the wood coating, like nano zinc oxides or nano titanium oxide, can increase the wood's durability, high durability, and UV absorption. As well as reduce water absorption. However, by allowing chemicals to penetrate deeper into the wood and preventing excessive leaching, the use of nanoencapsulation in wood preservatives could improve the impregnation of wood with pesticides. This increases the resistance of treated wood to agents that cause biodegradation. One of Malaysia's key sources of economic growth is the wood-based industry [52]. There are numerous untapped potentials in forests, which are the source of many lignocellulosic materials that could be utilized to produce environmentally friendly, biodegradable nanosized materials with several fascinating uses, such as in the wood-based industry. Application industries. The market for wood-based products might also make use of a variety of widely accessible nanomaterials to improve the functionality of currently available items or to develop brand-new, higher-value products from the forest [53]. With the right care, wood can also be used outdoors in addition to indoor applications. It takes a refining process that incorporates other elements, or "additives," to turn wood from a raw resource for engineering with industrial applications. The majority of wood-based goods come finished with additives. These additions can be coatings that provide protection, coatings that enhance aesthetic appeal, preservatives that protect against fire or biological elements like fungi and insects, or even plastics that enable the development of novel goods. Wood surfaces are exposed to numerous chemicals when utilized outside, thus protection is crucial [54]. Science-related equipment and novel materials with nanoscale structures make up the majority of current nanotechnology applications. These innovative materials are presently used in a wide range of manufactured goods as well as in cosmetics, health care, and medicine. These new technologies are also significantly fueled by the electronics and information technology sectors [54]. Due to its fibrous character, wood has been utilized for a variety of purposes for ages. Because of its strong strength in combination with low weight and some longevity, it is regarded as a major raw material in construction and comes in a variety of colors and densities. As a result, it is a raw material that may be utilized for both interiors and, with proper processing, outdoor applications. However, wood has two key drawbacks that prevent it from being used more widely. These are its vulnerability to microbial biodegradation and its dimensional instability when exposed to a range of moisture contents. The majority of wood species quickly disintegrate due to biological processes; fungi are responsible for the majority of biological deterioration. Wood experiences dimensional and structural instability as a result of changing moisture conditions [55]. The creation of wood and plant-derived lignocellulosic nanoparticles, as well as the change of wood's surface or bulk by nanoparticles, are two examples of how wood science and nanomaterials science intersect [56]. Wood is a raw material that trees naturally create that is plentiful on the planet, sustainable, biodegradable, and biocompatible, but because of its constituent parts, it is also chemically reactive. Wood is at the forefront of raw materials, dominating among those that are most environmentally friendly because of its remarkable intrinsic qualities [57]. Since a significant quantity of CO2 that is fixed in the xylem during wood production is kept from being released into the atmosphere for some time, the use of wood in long-lasting applications has an indirect positive impact on the environment. The coordinated expression of various structural components, which are defined by five successive phenological phases, is what causes wood to form. Cell expansion, cell wall thickening, and cambial cell division [57]. Wood is one of the most suitable and adaptable raw materials for a multitude of uses due to its fibrous character. However, due to two characteristics—dimensional changes caused by varying humidity and susceptibility to microbial biodegradation—it cannot be used in a wide range of applications. Wood has a variable moisture content, which causes dimensional and conformational instability. This can affect how well other materials, such as adhesives and surface coatings, work with wood [58]. A good potential to maximize the value of the forest resource is presented by the creation of value-added wood products from low-quality resources using modern technology, which also helps the Canadian wood industry's competitiveness abroad. To enhance some value-added wood properties including wood surface hardness, abrasion resistance, and dimensional stability, combining nanotechnology with a chemical impregnation process becomes particularly tempting. A new strategy to enhance the wood quality features crucial to value-added applications has been made possible by combining nanotechnology with the conventional impregnation procedure [59]. Over the past few decades, wood-derived biopolymers have garnered a lot of interest due to their plentiful and adaptable qualities. Cellulose, hemicelluloses, and lignin, the three main components that may be easily separated, are seen to be strong contenders to replace and advance chemicals and materials derived from oil. The creation of wood pulp-derived nano cellulose creates a possibility for the creation of innovative materials and nanotechnology applications. The development of 3D modeling methods for biopolymers produced from wood is currently the focus of increased research. These biopolymers will be used in a variety of novel applications, including the use of biomaterials for numerous biological purposes, as well as the development of innovative composite materials for electronics and energy systems [60]. The majority of economic sectors can use nanotechnology, and it promotes the growth of new enabling sciences. It is now possible to create new materials and goods in previously unthinkable ways thanks to the capacity to examine materials in nanoscale detail and regulate how things are built there. The preparation, characterization, material characteristics, Processing of polymer/cellulose or cellulose/cellulose nanocomposites: crystallization behavior, melt rheology, and processing from an academic and industrial perspective. Cellulosic materials are advantageous because they are abundant, renewable, have a nano fibrillar structure, can be made multifunctional, and self-assemble into precise patterns.

Materials have a lot of potential as nanomaterials [61]. Wood modification is now widely acknowledged as providing improved wood qualities and resolving problems with natural wood such as dimensional instability and biodegradability. Common wood alteration techniques include chemical, impregnation, and heat methods, and the qualities they produce differ [62].

2.7 Nanotechnology applications with a focus on drilling engineering in the oil and gas industries

According to Ali, et al. [63] Solvent evaporation, nanoprecipitation, salting out, Polymerization of emulsions and mini-emulsions, electrohydrodynamic atomization, the use of supercritical fluid technology, and the production with the help of Nano-emulsion template were some of the techniques used in the past to prepare nanoparticles. The most popular method for creating nanoparticles was solvent evaporation, which was also the first method to be used in this regard. Compound solutions were created in the emulsions during this process, and chloride and chloroform were used to advance volatile solvents. The organic chemical, which has a better pharmacological medication profile and encourages particles to be smaller than 500 nm, has now taken its position [64]. After the solvent has evaporated, the emulsion is ready when it transformed an interruption of nanoparticles, and the solution is then allowed to diffuse through a continuous portion of the emulsion to carry out conventional modes of operations, such as single emulsions like oil-in-water and double emulsions [65]. Such methods use ultrafast homogenizations either by magnetic stirring at a constant rate, high temperatures, or at lower pressure, which forms coagulated nanosized particles that are then collected by activity and laundered. Encourage the obviation of surfactants, and ultimately the product is preserved. Listed a few important and noteworthy uses for nanoparticles, such as drug delivery, imaging, solar cells, drilling, and improved oil recovery. Nanoparticles can help by stabilizing foams and emulsions, changing wettability, reducing oil viscosity, and lowering the surface of reservoir rock's surfactant adsorption and interfacial tension [66].

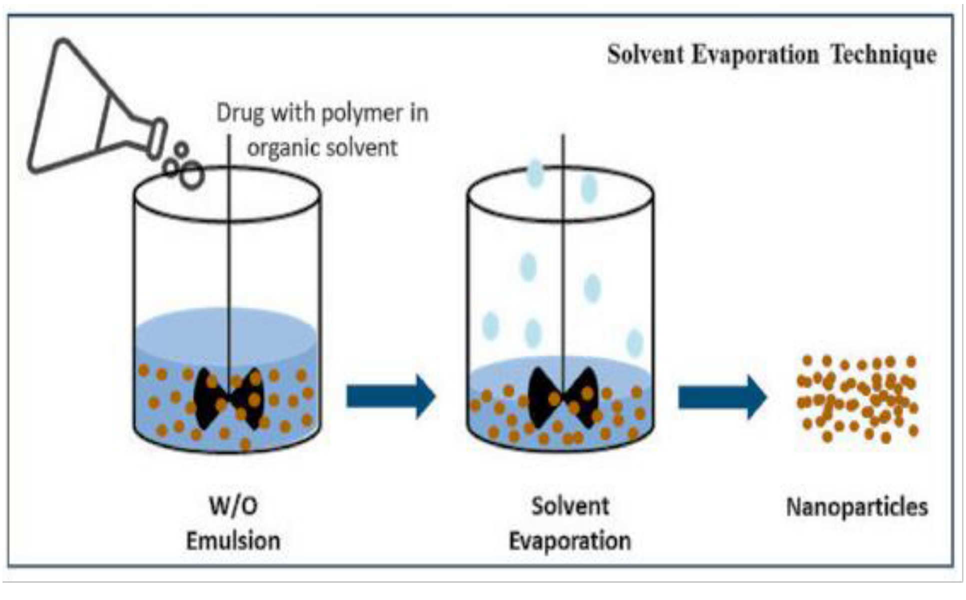

Figure 1. Nanoparticle preparation method using solvent evaporation

Peng et al. [67] investigated the numerous uses of nanotechnology, including nanoelectronics, nanomedicine, and nanodevices, which have been successfully deployed. The oil and gas sector must enhance oil recovery and make use of unconventional resources. It is getting harder to justify such investments when the price of crude oil is low and depressed since the cost of research and oil production is under so much pressure. Most people think that nanotechnology could be used to create novel, additional effective nanomaterials to overcome these technical obstacles. Exploration, drilling, production, refining, and wastewater treatment have all received increased financial support from the federal government and the international oil sector. EDiasty et al. [68] said that the applications of nanotechnology have penetrated numerous petroleum-related fields, including drilling, completion, production, exploration, processing, refinery, etc. For illustration, enhanced field characterization techniques have been made possible by the rapid development of nano-sensors to improve the resolution of subsurface imaging. Nanotechnology also has a significant impact on the production stage, enhancing the recovery of oil by molecular alterations, and controlling the interfacial properties. Likely similar way, it also offers fresh ideas for better post-production procedures. The application of nanotechnology to the petroleum sector has increased because of its positive outcomes and compatibility with various E&P operations. Nanomaterials have been assessed to comprehend the process, performance, and economic viability, particularly for well-cementing activities [69]. The researchers searched for novel and affordable ways to offer more energy and optimize its usage due to the rising demand for energy brought on by population increase, civilization, and the limited availability of fuel sources. Studies on oil upstream are primarily concerned with maximizing exploration, drilling, production, recovery, and the discovery of new reserves. Nanotechnology has recently sparked a revolution in several fields of science and engineering. It carries out the creation, testing, production, and use of materials and technologies based on nanoscale dimensions, which range from 1 to 100 nm [70].

2.8 Use of nanotechnology in sensor-based foodborne pathogens detection

Kumar et al. [71] examined and said that because of the emergence of serious food-borne diseases, eating food that has been contaminated by microbes offers serious health risks. To avoid these issues, it is necessary to accurately detect and identify harmful bacteria and poisons in food. Because of this, researchers have been able to create nano biosensors using various nanomaterials and composites to increase the sensitivity and specificity of pathogen detection. Researchers have been able to use cutting-edge technologies in biosensors to convey signals to increase their efficiency and sensitivity thanks to the application of nanomaterials [72]. Because of their special chemical, and magnetic, qualities that are mechanical and optical, Nanomaterials with increased sensitivity and specificity of detection, such as carbon nanotubes, magnets and metal, dendrimers, graphene nanoparticles, and quantum dots, are widely used to make biosensors [73].

2.9 Nanofilms

To make thin films water-repellent, anti-reflective, self-cleaning, ultraviolet or infrared-resistant, anti-fog, anti-microbial, scratch-resistant, or electrically conductive, several nanoscale materials can be utilized. Currently, nanofilms are utilized to cover or cure surfaces on cameras, computer displays, and eyeglasses [74]. Since its discovery, magnetism has attracted humans as a particularly spectacular physical phenomenon. To date, all parts of our society have undoubtedly benefited from its utility in applications. For the vast majority of the time that we have exploited magnetic phenomena, the implementation has been macroscopic, at least down to bulk engineering dimensions. However, over the past two decades, a diverse array of sub-microscale concepts, Applications, and tools have emerged. In terms of its effects on our society and the digital era, data storage is the most apparent [75].

3. Contribution

The contributions of nanotechnologies and their applications in science have solved various puzzles and challenges globally. The extent of growth achieved in computing, medicine and energy including other areas have become possible through the development of nanoparticles and nano-medicine which have helped to solve various problems.

4. Conclusion

Scientists and engineers in our country are developing new applications for nanotechnology to enhance the environment in which we live. These scientists picture a world in which atomic and molecularly precise new materials offer practical, affordable ways to utilize renewable energy sources and preserve the environment. They witness doctors treating conditions like cancer, heart disease, and diabetes with stronger, safer medications and spotting sickness in its earliest stages. They envision cutting-edge technologies that will shield our civilian population and military personnel from nuclear, biological, and chemical weapons. Nanotechnology is already creating a wide range of useful materials and pointing to breakthroughs in many sectors, despite the many scientific hurdles that still need to be overcome. It has made scientific inquiry at the molecular level possible, opening up a world of fresh possibilities. The benefits of nanotechnology have been captured by various researchers. More so, the application of nanotechnologies in modifying systems' performances and their operations has gained considerable momentum. Hence, there is a need to embrace more research in ways to improve the applications of nanotechnologies knowledge in engineering, computing, electronics, etc.

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