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Nanotechnology Concepts Importance and its Application

Kuldeep Kumawat[1], Dr. Vishal Shrivastava[2], Dr. Akhil Pandey[3], Er. Ram Babu Buri[4]
[1,4]B.TECH. Hosteler, [2,3]Professor
Department of Computer Science & Engineering
Arya College of Engineering & I.T., Jaipur, India
568kuldeeps@gmail.com, vishalshrivastava.cs@aryacollege.in, akhil@aryacollege.in

Abstract: *In nowadays, research in nanoscale science has been greatly developing and obtaining more interests. Numerous research activities in the last two decades focus on exploring nanoscience, understanding the fundamentals, and developing technical solutions. Materials in nanoscale showed remarkable and superb properties that are completely different from those when the material in the bulk condition. This makes nanotechnology to hold a great promise in effecting profound scientific, medical, energy, economic and even cultural change on society. Almost all countries are placed long and short term strategic plans as to obtain more experience and carefully examine the potential implications of nanotechnology and its strategic benefits. Consequently, research indicators on this technology indicate that some developing countries compete with the world's largest countries in the control of this technology. This paper, however, provides an introduction to the nanotechnology, and also discovers the current status of the research on this particular field globally and in the Arabic region. The real status of the scientific research on the nanotechnology in Libya correspondingly is realized. Steps required by the Libyan authorities and research principles to fill in the gape in this area are also expressed.*

Keywords: nanoscale science

I. INTRODUCTION

Nanotechnology has become a competitive scientific technology that most developed countries compete to control. The research and development in this particular field of technology has impacted every aspect of modern human life. More and diverse areas of research have been continuously increasing and gaining the interest of researchers and scientists to apply this kind of technology and benefit from energy; agriculture; petroleum industry; food industry; and probably the strongest field is medicine and healthcare.

Nanotechnology refers to the science and technology in which matter is controlled on a nanoscale. It is commonly attributed to the technologies leading to the production of nanoscale materials at nanometre dimension (10^{-9} m). The nanoscale is consensually considered to cover the range of 1 to 100 nm.

According to the US National Nanotechnology Initiative (NNI), nanotechnology is “the understanding and control of matter at dimensions between approximately 1 and 100 nanometres, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modelling, and manipulating matter at this length scale.”

Yet, numerous definitions of nanotechnology have migrated and expanded with the passage of time. For instance, one definition is expressed as: “Nanotechnology is the design, characterization, production and application of materials, devices and systems by controlling shape and size of the nanoscale.”

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While a slightly different nuance is given by: "The deliberate manipulation, precision placement, measurement, modelling and production of matter at the nanoscale in order to create materials, devices and systems with fundamentally new properties and functions."

Another different definition, though floating around, is: "The design, synthesis, characterization and application of materials, devices and systems that have functional organization at least one dimension on the nanometre scale."

Obviously, the definitions, however, should provide some form of proactive engineering to the term nanotechnology. Nevertheless, to avoid the debate about the definition as it is not the particular scope of this paper, it would be better to suggest that a certain technology can be considered nanotechnology only if it involves all of the following three attributes: first, research and technology development at the atomic, molecular or macromolecular levels, in the scale of approximately 1–100 nm range; second, creation and use of structures, devices and systems that have novel properties and functions because of their small and/or intermediate size; and finally, an ability to control or manipulate on the atomic or the nanoscale .

This paper provides an introduction to the basic principles and applications of nanotechnology. It also discovers the current status of research on this particular field globally and in Arabic countries. The real situation of the scientific research on nanotechnology in Libya is finally concluded, and steps required by authorities and research principles to motivate the research in this area are expressed.

II. IMPORTANCE OF NANOTECHNOLOGY

Nanotechnology is considered as a powerful tool and technique in medical technology as well as almost every filed life. This kind of technology develops so fast; while its applications diverse to touch all branches of science, engineering and industries. The momentum of nanostructures stems from the fact that new materials with absolutely new properties can be developed. Properties of a matter depend strongly on how atoms are arranged in space; e.g. if atoms in coal (Carbon) is rearranged, it could make diamond. Therefore, nanotechnology holds great opportunities for innovation in, virtually, every industry and application. New materials and advanced devices of a desirable properties and functions can be developed for numerous applications using this technology. The main aspects that make nanotechnology attractive to researchers are the fact that it is relatively cheap, can be manufactured in bulk with lower energy; the ability to control the material's properties by controlling its particles size and structural form as well as controlling the conditions and methods of preparation; and relatively safe in terms of use for people and environment.

III. NANOFACTURE

There is a wide variety of technologies that have the potential to produce nanomaterials with different degrees of quality, speed and cost. Yet, grain size, shape and structure of the required nanomaterials are the main factors restrict the selection of the technology . Almost all of these techniques fall into the main categories . The topdown methods mostly require large (and also expensive, needs considerable concentrations of capital) installations . Traditionally, scaling-down processes are based on process that include grinding or etching and utilise an ultraprecision engineering. Mechanical stiff parts are used to ultra-precisely shape objects. While on the other hand, for semiconductor processing a very highquality thin films are deposited, either physical vapour deposition (PVD) or chemical vapour deposition (CVD), with nanometre control, perpendicular to the plane of a substratum . Sophisticated technologies, e.g. exposure to a plasma, or ions implantation, are employed to modify existing surfaces of materials.

The other approach is known as molecular manufacturing; also known as "pick and place" or bottom-to-bottom methods, literally construct things atom-by-atom .

The third approaches, known as bottom-up or selfassembly, are based on creating objects that capable of spontaneously assembling into useful structures. Precursors are gathered in random positions and orientations, and supply energy to allow them to sample configuration space. Once the precursors are in position, the bonds connecting them are strengthened and the final object is fixed permanently .

IV. INFLUENCE OF THE SIZE ON THE MATERIAL

Owing to the small size of the building blocks (particle, grain, or phase) nanomaterials demonstrate unique mechanical, optical, electronical, and magnetic properties . Properties of nanomaterials depend on : fine grain size and size distribution (<100 nm); the chemical composition of the constituent phases; the presence of interfaces, more specifically, grain boundaries, hetero-phase interfaces, or the free surface; and lastly interactions between the constituent domains. Changes in the size-dependent properties of a matter are observed due to the fact that wavelike properties of electrons inside the matter and atomic interactions are influenced by the size of materials at the nanometre scale. Confinement of the DeBroglie wavelength of charge carriers inside nanomaterials could also lead to quantization effect . As the size decreases, the ratio of atoms on the surface increases. Such atoms are high energy surface atoms and very reactive. This also creates a high surface to volume ratio leading to a tremendous improvement in chemical properties. Platinum nanoparticles, for example, are efficient catalysts for many reactions whereas platinum bulk sheets are sufficiently inert . Large surface to volume ratio means subtle changes to the surface due to addition of numerous atoms or molecules leading to dramatic alterations of physical properties. Number of fields, including magnetism, luminescence and renewable/alternative energy to sensors as well as photo-catalysis, will benefit from capitalizing on the surface–volume relationship. The possible enhancement of physical properties is therefore due to quantum size and clustering interface effects . Figure 1 shows how surface volume ratio changes with particle size.

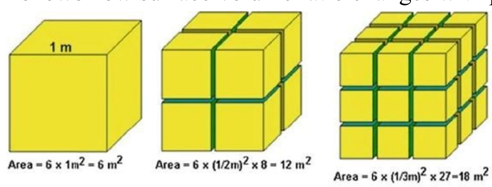

Figure 1: The surface volume ratio changes with particle size.

V. NANOTECHNOLOGY AND ITS APPLICATION

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.

5.1 APPLICATIONS IN ELECTRONICS

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 . 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. 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

5.2 APPLICATION IN MEDICAL AND HEALTHCARE

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. 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 . These applications either make use of the special characteristics of nanoparticles as pharmaceuticals or drugrelated 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.

5.2.1 DRUG DELIVERY TECHNIQUE

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. 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. 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.

5.3 APPLICATION IN TECHNOLOGY

Nanotechnology is enhancing alternative energy sources and utilizing existing energy sources to help the world's expanding energy demands. . 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 . 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 . 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 . 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 . 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 . 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 . 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 . 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 .

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5.4 APPLICATION IN MODERN TEXTILE

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 realworld 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. 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 . 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 . 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. 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. Nowadays, new highperformance 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 . 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 . Nanotechnology has the potential to make textiles multipurpose by enabling the development of materials with distinctive properties including antimicrobial, odor- and odorrepellent, flame- and UV-protective, waterrepellent, and wrinkle-resistant . 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 . Nanotechnology is employed in the creation of multifunctional textiles and materials with unique properties, such as odorand 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. 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

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sacrificing the intrinsic qualities of textiles . 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 . 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 . 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 . 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 . 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) . 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 lightemitting fabrics . 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 . 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 longlasting 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 .

5.5 APPLICATION IN AGRICULTURE

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. the controlled chemical release. In addition to improving solubility and soil dispersion, nanosized o mineral micronutrient formulation can also reduce absorption and fixation, increase bioavailability, increase NUE, and conserve fertilizer resources

AREA OF APPLICATION	USES
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.
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
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 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

VI. 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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