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A Comprehensive Review and Insight into the Latest Advancements in Nanotechnology

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Nanotechnology is an innovative field focused on manipulating matter at the molecular and atomic scale, typically below 100 nanometers. It enables the design, creation, and application of systems with enhanced properties due to nanoscale precision. Molecular nanotechnology (MNT) integrates engineering with molecular chemistry and physics, offering substantial advancements in medicine, environmental cleanup, and other fields. Significant milestones include the invention of the Scanning Tunneling Microscope (STM) in 1981 and Eric Drexler's popularization of the field with his book "Engines of Creation." Nanotechnology has revolutionized medicine with improved drug delivery systems, diagnostic tools, and medical imaging. In environmental science, it has enabled advanced filtration systems and pollution control methods. Different types of nanoparticles, such as metal, semiconductor, polymeric, lipid, carbon-based, and magnetic nanoparticles, have unique properties and applications across various industries. Despite its benefits, nanotechnology raises health and environmental concerns, leading to the emergence of nanotoxicology and nanomedicine to study and mitigate hazards. The evolution of nanotechnology has significantly impacted healthcare, electronics, energy, and materials. Regulatory challenges and health concerns present obstacles to commercialization, requiring collaborative efforts and proactive risk management.

Keywords: Atomic level manipulation; Molecular scale; Nanotechnology; Nanoparticles; RFID.

Nanotechnology is a cutting-edge discipline that includes both highly novel concepts and contemporary developments, with the goal of designing functional systems at the molecular scale. It entails the painstaking creation, description, manufacturing, and application of systems, devices, and structures that are precisely manipulated in size and shape to produce higher qualities[1-3]. This multidisciplinary field includes methods and resources for building things using top-down and bottom-up strategies, enabling the development of extremely complex products. Fundamentally, qualities can be altered at a remarkably small scale thanks to nanotechnology, which opens a wide range

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of potential uses[4-5]. Molecular nanotechnology is a rapidly developing field that combines engineering disciplines including computer science, electrical engineering, mechanical design, structural analysis, and systems engineering with concepts from molecular chemistry and physics[6]. Tumor development and metastasis are the hallmarks of cancer progression; these events are marked by increased tumor cell invasiveness and growth rate. Even though cancer therapies including chemotherapy, radiation, immunotherapy, and surgery have been used for a long time to stop the spread of the disease, problems with solubility, stability, limited biodistribution, metabolism, chemoresistance, and toxicity sometimes cause treatment to fail[7-8].

Nanotechnology is a field of applied science and technology focused on controlling matter at the atomic and molecular scale, typically 100 nanometers or smaller, and creating devices or materials within this size range[9-10]. In the future, nanotechnology is expected to involve the construction of machines and mechanisms with nanoscale dimensions, known as Molecular Nanotechnology (MNT)[11-12]. Molecular manufacturing, a key aspect of MNT, involves using precisely engineered, computer-controlled nanoscale tools to build many improved tools and products with meticulously designed nanoscale features[13].

The Foresight Institute has recently proposed an alternative term, “Zetta technology,” to represent the original concept of nanotechnology. At its core, MNT entails the deliberate and systematic construction of two things, molecule by molecule, at the most fundamental technical level[14-15].

Objectives

Main objective of the current study focused on understanding of nanotechnology, its core principles, different types of nanoparticles, their unique properties, and their applications in various sectors and its multidisciplinary approach and historical evolution of nanotechnology, emphasizing key milestones and notable contributions. Additionally, its current and potential future applications of nanotechnology in industries such as healthcare, electronics, environmental science, and manufacturing.

History of Nanotechnology[16-17]

The term “nanotechnology” was first used in 1974 by Japanese scientist Professor Norio Taniguchi at an international symposium on industrial production held in Tokyo. Taniguchi coined the phrase to refer to the nanoscale ion beam milling and semiconductor manipulation method. He defined nanotechnology technically by stating that it involves the processing processes of dissociation, merging, and material deformation[18].

The “golden era” of nanotechnology began in 1981 when Gerd Binning and Heinrich Rohrer invented the Scanning Tunneling Microscope (STM), which made it possible to identify individual atoms (“Scanning the past,” 2013). The discovery of Buckminsterfullerene C60 (buckyballs) by Robert Curl, Richard Smalley, and Harry Kroto further accelerated this age[19].

One of the main contributors to the advancement of nanotechnology concepts was Eric Drexler of Massachusetts Institute of Technology (MIT). Drexler gave nanotechnology a commercial definition in his 1986 book “Engines of Creation: The Coming Era of Nanotechnology,” where he defined it as engineering on the billionth of a meter scale[20]. To increase public understanding of nanotechnology concepts and ramifications, Drexler established the Foresight Institute after the book’s publication.

Throughout the late 1980s and early 1990s, significant discoveries and inventions further propelled nanotechnology’s development. These advancements led to significant improvements in nanotechnology research, design, and publication output, shaping its trajectory for future growth and innovation.

Nano scale vs. atomic scale[21-22]

While one nanometer is relatively large compared to the atomic scale, it still offers significant opportunities for manipulation and assembly. At approximately 0.1 nanometers in diameter, an atom represents the fundamental unit of matter, with its nucleus even smaller at about 0.00001 nanometers. Atoms serve as the foundational building blocks for all substances in the universe. Nature exhibits remarkable precision in molecular assembly, evident in the construction of complex structures such as the human body from millions of living cells. These cells function as nature's nanomachines, orchestrating intricate processes at the molecular level.

At the atomic scale, elements exist in their most rudimentary form, representing the basic constituents of matter. However, the nanoscale offers a realm of greater complexity and potential. Here, atoms can be strategically arranged to create a wide array of materials and structures. What distinguishes the nanoscale is its capacity for assembly - it marks the threshold where atoms can be organized to form functional and practical entities. It is through the manipulation and arrangement of atoms at the nanoscale that we unlock the ability to create innovative and useful technologies[23-24].

Nanotechnology's Present and Future Applications[25-29]

With experts projecting significant contributions to economic growth and employment creation, nanotechnology is an emerging subject set for exponential growth. Numerous studies have highlighted the risks and enormous promise of nanotechnology in a variety of technological fields. By using nanoparticles, nanotechnology has transformed processes related to bioavailability, production, packaging, and product shelf life in industries like food and cosmetics. Food-borne germs can be eliminated with the use of nano-sensors, like zinc quantum dots, which improve food safety and quality[29].

Furthermore, by utilizing designed nanoparticles to promote a world free of pollution, nanotechnology has achieved tremendous advancements in environmental cleanup. Nanotechnology has a lot of potential applications in biotechnology, medicine, and research. Medical treatments have been transformed by the development of nanoparticle-based medical instruments, such as drug delivery systems, imaging probe, and diagnostic biosensors. These tools have also made medical operations more convenient, safe, inexpensive, and comfortable[30-32].

Despite its widespread adoption and tangible benefits, the ubiquitous exposure of humans to nanoparticles has raised significant concerns regarding potential health and environmental risks. Consequently, disciplines such as nanotoxicology and nanomedicine have emerged to address these concerns. Nanotoxicology focuses on studying and mitigating the hazardous effects of nanoparticles on human health and the environment. On the other hand, nanomedicine explores the benefits and risks associated with the utilization of nanomaterials in medical applications, encompassing areas such as medical diagnosis, bioimaging, and tissue engineering. Enhanced drug delivery, early cancer cell detection, and reduced inflammation are among the notable benefits offered by medical nanomaterials. However, ongoing research is essential to fully understand and manage the potential risks associated with nanotechnology[33-37]. Role of nanotechnology in drug discovery has been illustrated in Figure 1.

Different types of Nanoparticles[39-42]

Nanoparticles exist in diverse forms, each possessing distinct characteristics and uses, as demonstrated in table 1 and figure 2. Metal Nanoparticles are particles of metals like gold, silver, and platinum, typically ranging from 1 to 100 nanometers in size. They exhibit distinct optical, electronic, and catalytic properties, making them useful in fields such as catalysis, sensing, and biomedical applications[43-45]. Semiconductor Nanoparticles, such as quantum dots, possess semiconductor properties, with a size-dependent bandgap. They find applications in electronics, solar cells, and biological imaging due to their tuneable optical and electronic properties[46-47]. Polymeric Nanoparticles composed of polymers or polymer-drug conjugates, these nanoparticles are used for drug deliver, gene therapy, and imaging. They offer controlled release of therapeutic agents and can be tailored for specific targeting and biocompatibility[49-51]. Lipid Nanoparticles, Liposomes and lipid-based nanoparticles, are commonly used in drug delivery systems due to their biocompatibility and ability to encapsulate both hydrophilic and hydrophobic drugs. They can protect drugs from degradation and enhance their bioavailability[52-53]. Carbon nanotubes, fullerenes, and graphene are examples of Carbon-based nanoparticles. They possess exceptional mechanical, thermal, and electrical properties, leading to applications in electronics, aerospace, energy storage, and biomedical fields[54]. Magnetic Nanoparticles typically composed of iron oxide or other magnetic materials, exhibit magnetic properties. They are used in magnetic resonance imaging (MRI), targeted drug delivery, hyperthermia therapy, and magnetic separation techniques[55-58]. Quantum dots are semiconductor nanoparticles with unique optical and electronic properties arising from quantum confinement effects. They find applications in displays, lighting, biological imaging, and solar cells due to their tunable emission wavelengths and high quantum yields.

Nanotechnology and Neuronal Molecular Insights[59-61]

Nanotechnology offers innovative ways to study neurons at the molecular level, providing insights into their structure, function, and interactions. By leveraging nanoscale tools and techniques, researchers can explore the intricate workings of neurons with unprecedented precision and the same has been illustrated in table 2 and figure 3. The creation of imaging instruments at the nanoscale is a significant use of nanotechnology in neuroscience. These instruments enable the observation of individual molecules within neurons and provide a remarkable level of detail visualization of neural structures and activities. For instance, sophisticated microscopy methods like single-molecule imaging and super-resolution microscopy may show how proteins and neurotransmitters are arranged within synapses, the connections between neurons[62-63]. Furthermore, the targeted delivery of therapeutic medicines to neurons is made easier by nanotechnology. Potential treatments for neurological illnesses may be available if nanoparticles are designed to selectively interact with neuronal targets and pass the blood-brain barrier. Furthermore, real-time monitoring of neural activity with nanoscale sensors yields important information about brain function and pathology[64-65].

Encourage ring Results and Advancements[66-67]

This review delves deeply into the possible uses of nanotechnology in product creation. For clarity, these opportunities are divided into the following categories: 1) Energy and Electronics; 2) Materials; 3) Bio/Medical; 4) Food and Agriculture. The opportunities described in each part are briefly described below. The various applications of Nanotechnology have been revealed in Table 3.

Energy and Electronics Opportunities[68-70]

Lewis presents a thorough analysis of a workable artificial photosynthetic system that has two complementary photosystems that can both add voltage and match current. These systems present a viable method for producing solar fuels when paired with various catalysts. Furthermore, as Rajeeva and Zheng have shown, Nano photonics has potential for a wide range of uses, such as guided nanofabrication, real-world applications, and molecular-scale measurements. Iocozzia and Lin introduce novel "nanoreactors" that can create distinct organic nanostructures for use in photovoltaics and optics.[71-73]

Material Opportunities[74-76]

To produce hybrid materials with a variety of uses, including medication administration and controlled nanoparticle creation, Lei et al. describe their method of merging polymer single crystals with nanoparticles. To increase the usefulness of common nanoparticles like titania and silica in toothpastes and sunscreens, Rashwan and Sereda report on surface modifications of these particles. In order to meet the urgent needs in the production of high-tech and energy devices, Florek et al. report the creation of nano-structured hybrid materials for the extraction of rare earth elements (REE). In their assessment of developments in gas separation membranes, Liu et al. highlight the significance of selective layers at the nanoscale in membrane technologies[77-78].

Bio/Medicine Opportunities[79]

Spherical nucleic acids (SNAs) have a lot of potential in biology and medicine. Mirkin highlights some of these uses, such as in medical diagnostics and therapies. Nath investigates multipurpose magnetic nanoparticles for use in drug delivery, therapy, and diagnosis in medicine. The creation of soft nanoparticles as drug carriers for intravesical treatment for bladder cancer is covered by Neoh et al. Harris examines the use of drug delivery and cancer treatment utilizing cell membrane-coated nanoparticles, emphasizing the improvement of in vivo circulation time and tumor targeting. In order to illustrate the potential of this technique for portable detection devices, Madiyar and Li develop a nanostructured dielectrophoresis (DEP) device for trapping virus particles and bacterial cells. Philbert highlights the many uses of nanomedical products and medications in medicine while reviewing those undergoing clinical testing[80-86].

Opportunities in Food and Agriculture[87]

The uses of nanotechnology in agriculture, such as postharvest uses, plant enhancement, soil management, and animal health, are reviewed by Cheng et al. With a number of products already on the market, nanotechnology is being investigated in the food industry for use in food processing, packaging, nutrient delivery, and water remediation, among other applications[88]. Despite not being treated in detail in this review, there is a wealth of current writing on this topic.

Evolution[89]

In the domain of Nanotechnology, a succession of developmental stages has been delineated, each engendering the subsequent phase through technological advancements and temporal progression. This iterative process facilitates the elucidation of Nanotechnology's evolutionary trajectory and its consequential ramifications on the commercial sphere (Figure 4). It is unequivocally

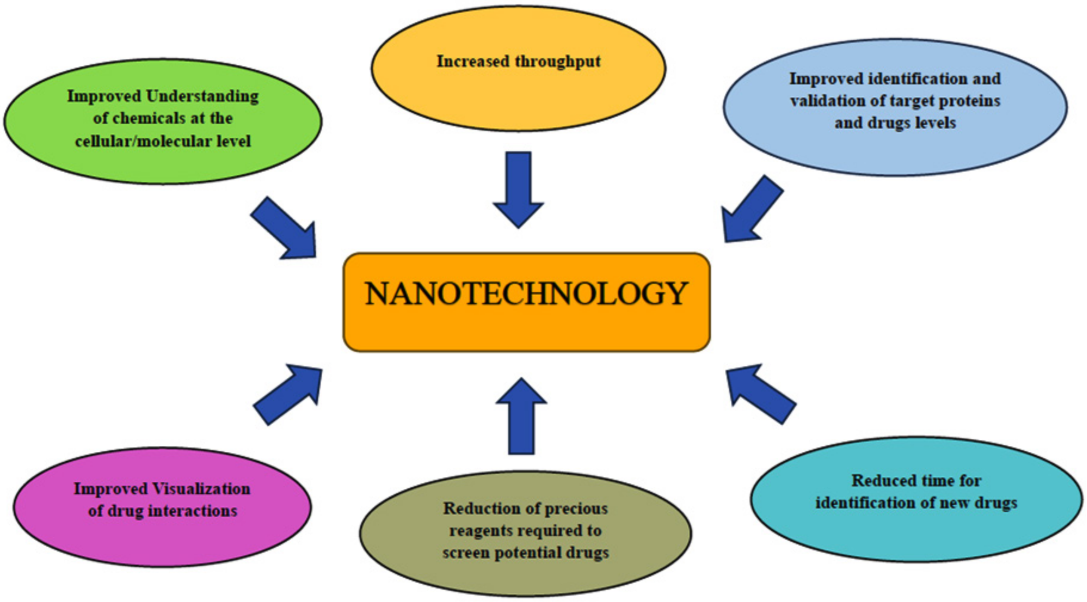

Fig. 1. Role of Nanotechnology in Drug Delivery
(Credit for figure 1: Amarpreet D. The Role of Nanotechnology in Drug Discovery. Drug Discovry world. 2006)

Table 1. Different Types of Nanoparticles

Nanoparticle Type	Properties	Applications
Metal Nanoparticles[43-45]	Optical, electronic, and catalytic properties	Catalysis, sensing, biomedical applications
Semiconductor Nanoparticles[46-47]	Tunable optical and electronic properties	Electronics, solar cells, biological imaging
Polymeric Nanoparticles[49-51]	Controlled drug release, targeting, biocompatibility	Drug delivery, gene therapy, imaging
Lipid Nanoparticles[52-53]	Biocompatible, encapsulation of hydrophilic and hydrophobic drugs	Drug delivery, protecting drugs from degradation
Carbon-Based Nanoparticles[54]	Exceptional mechanical, thermal, and electrical properties	Electronics, aerospace, energy storage, biomedical
Magnetic Nanoparticles[55-58]	Magnetic properties	MRI, targeted drug delivery, hyperthermia therapy
Quantum Dots	Tunable emission wavelengths, high quantum yields	Displays, lighting, biological imaging, solar cells

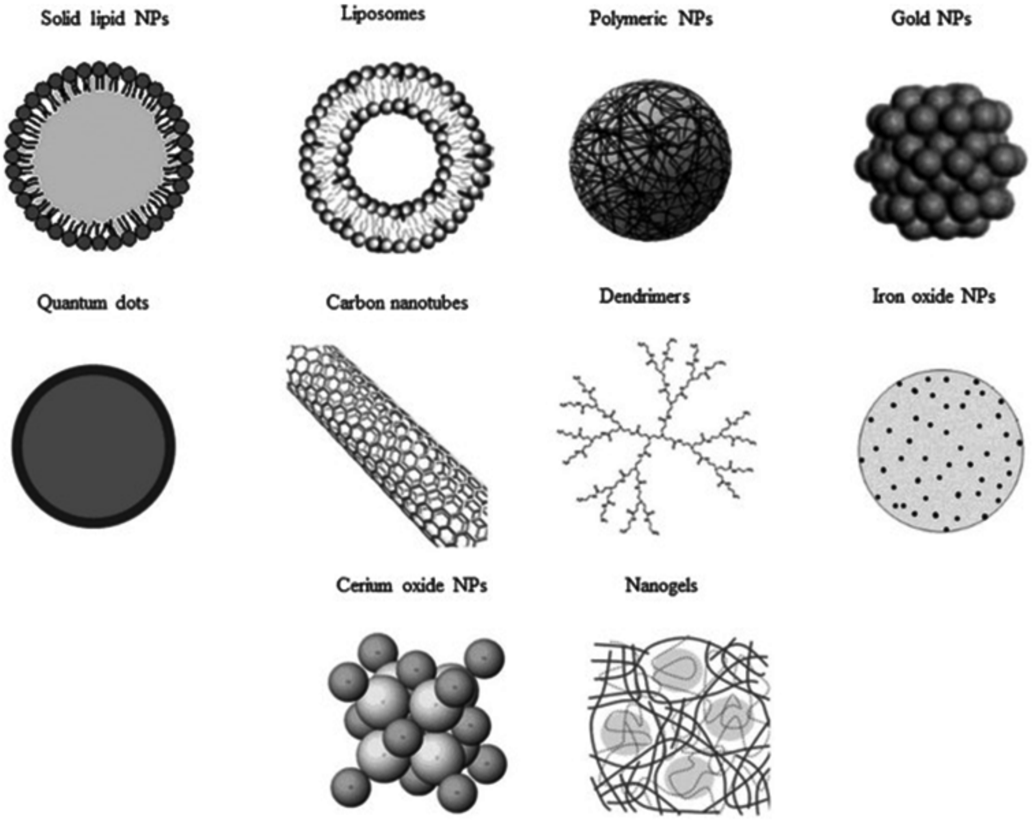

Fig. 2. Different types of nanoparticles[114]
(Credit for figure 2: Re F, Gregori M, Masserini M. Nanotechnology for neurodegenerative disorders. Nanomedicine: NBMedicine. 2012;8:S51–S58)

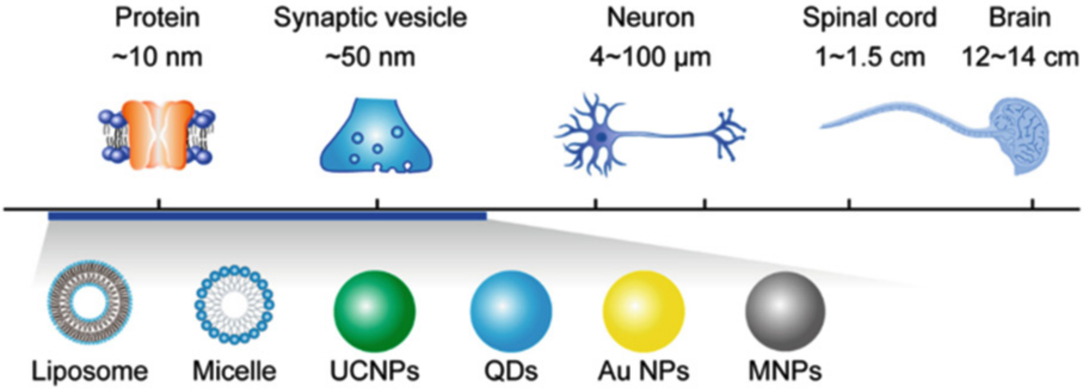

Fig. 3. View of Neurons at Molecular level by using Nanotechnology[115]
(Credit for figure 3: Fan H. Central Nervous System Nanotechnology. In: Gu, N. (eds) Nanomedicine. Micro/ Nano Technologies. Springer, Singapore. 2023; pp 978-981)

evident that perpetual advancement is underway, marking an inexorable march forward[89].

Approaches In Nanotechnology[90]

Bottom-up Approach: The bottom-up approach involves the construction of materials and devices using molecular components that self-assemble based on principles of molecular recognition. In essence, this method aims to organize smaller constituents into more intricate assemblies through chemical processes.

Top-down Approach: Contrarily, the top-down approach entails the fabrication of nano-objects from larger entities without precise control at the atomic level. In simpler terms, this approach involves the creation of smaller devices by utilizing larger ones to guide their assembly.

Applications[91]

In the contemporary era, Nanotechnology finds application across diverse fields and disciplines, exerting a profound impact on our daily existence. Its pervasive influence extends to every facet of our lives, from the objects we encounter to the food we consume, and even machinery that aids us in our tasks, all leveraging the principles of Nanotechnology. Figure 5 illustrates the involvement of nanotechnology in different industries.

Mechanical applications

In mechanical applications, solid lubricants are employed in environments where conventional lubricating oils cannot be used, typically in vacuum or oxidizing atmospheres. H-BN (hexagonal boron nitride) and graphite are widely utilized as solid lubricants in various industries (Figure 6). H-BN is particularly advantageous due to its low friction coefficient and high temperature tolerance in air, reaching up to 900°C. Nano-onion powder represents another exceptional solid lubricant option[92-93].

Chemical applications

In chemical applications, carbon nanotubes and carbon onions possess the capability to encapsulate various materials within their structures, offering shielding properties. This shielding is particularly crucial for safeguarding nano materials from environmental factors, notably oxidation (94). Furthermore, magnetic particles utilized in data storage can benefit from protection against exposure to air. Additionally, the utilization of these materials enables the synthesis of diverse hybrid nano composites, such as metallic nano roads within tube cavities. Nanotechnology operates within the manufacturing realm with a

Table 2. Impact of Nanotechnology on Key Industries

Industry	Impact
Healthcare[59-61]	Improved drug delivery leading to targeted therapies, Enhanced imaging techniques for early disease detection, Development of personalized medicine
Electronics[68-70]	Miniaturization of devices leading to more powerful electronics, Improved energy efficiency and performance in electronic devices
Energy[68-70]	Increased efficiency and affordability of renewable energy sources, Breakthroughs in energy storage technologies
Materials[74-76]	Development of lightweight and durable materials, Enhanced mechanical, thermal, and electrical properties
Environmental[87]	Cleaner water and air through advanced filtration methods

Table 3. Applications of Nanotechnology in Various Industries

Industry	Application
Healthcare[62-63]	Drug delivery systems, Nanoscale imaging and diagnostics, Tissue engineering
Electronics[68-70]	Nanoelectronics and nanodevices, Quantum computing, Flexible electronics
Energy[68-70]	Solar cells and photovoltaics, Energy storage systems, Fuel cells
Materials[74-76]	Lightweight and high-strength materials, Self-healing materials, Nanocomposites for improved properties
Environmental[87]	Water purification, Air filtration, Soil remediation

focus on the nanometer scale, ranging from 100 nm to 0.1 nm. Employing electromechanical system technology, nanotechnology facilitates the production of more refined components and parts for integration into microelectronic circuitry and control systems. Through the lens of a microscope, even the smoothest crystalline coatings, such as polished chrome, reveal irregular gaps between crystals. Nanotechnology plays a pivotal role in identifying and rectifying such defects.

Electronic applications

In electronic applications, electron sources play a vital role in various devices such as screens and electron microscopes. Carbon

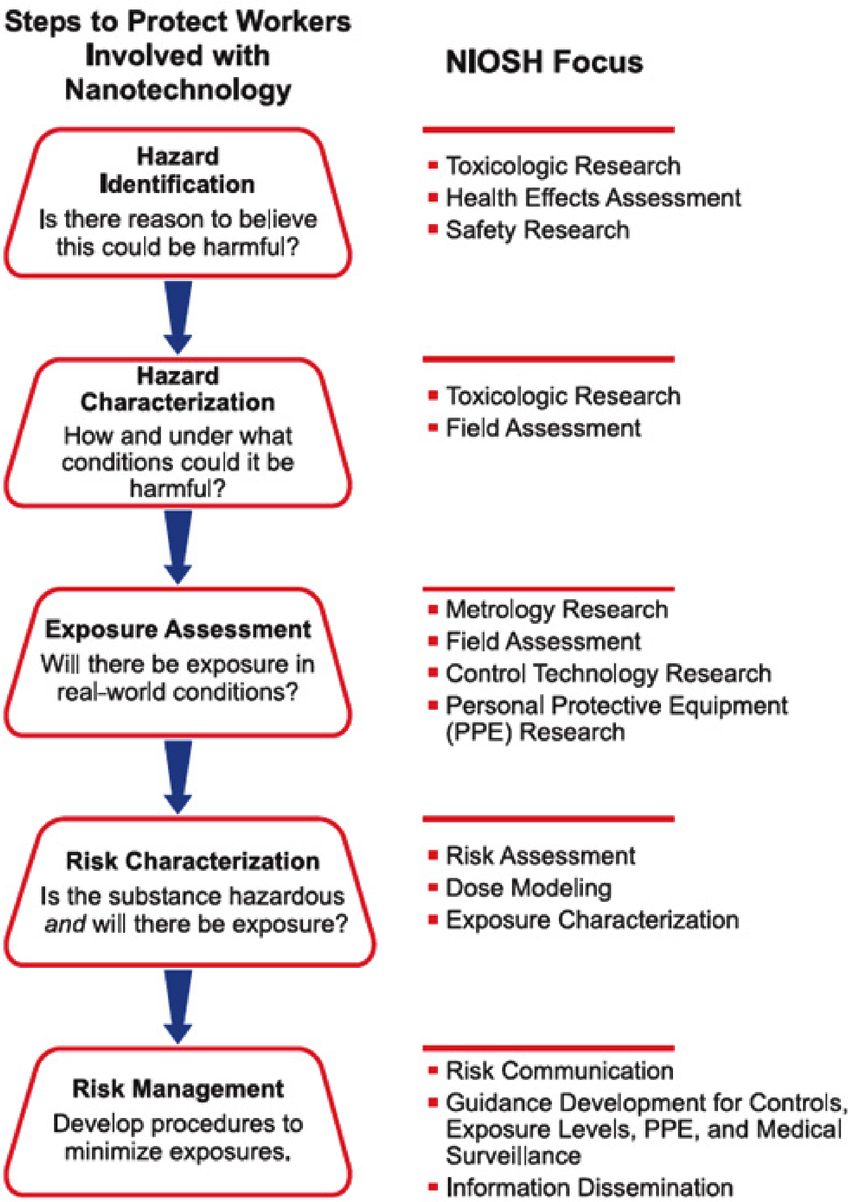

Fig. 4. Phases of Nanotechnology
(Credit for figure 4 : Asmatulu R. Toxicity of Nanomaterials and Recent Developments in Lung Disease. Bronchitis, Intech. 2011, DOI: 10.5772/16670

nanotubes exhibit the ability to emit a high current of electrons from their tips when subjected to a bias voltage. This emission is facilitated by the exceptionally low threshold voltage due to the curvature of the tip. Different post-synthesis methods have been employed to realize emission surfaces. Consequently, this application appears to be on the verge of commercialization[95].

Application of nanotechnology in machineries

Surface Coating

Recent advancements in surface coating technology include arc bond sputtering and

Fig. 5. Nanotechnology's Multidisciplinary Nature

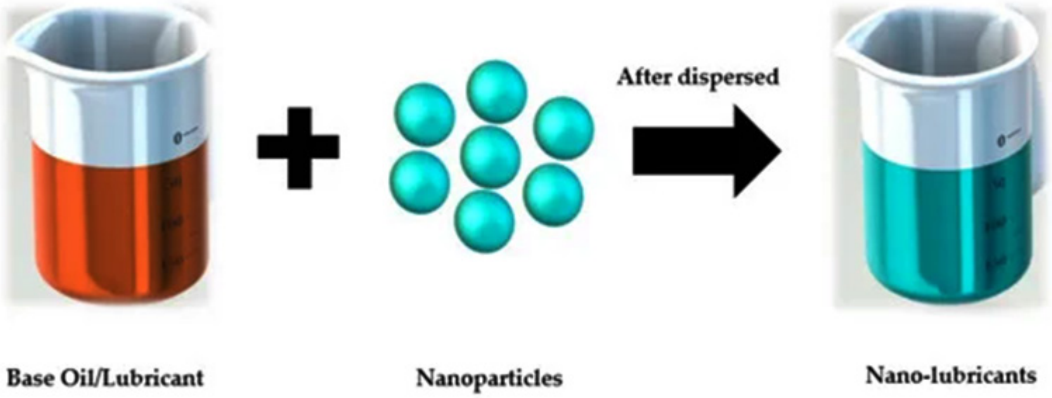

Fig. 6. Nano Lubricants
(Credit for figure 5: Jason YJJ, How HG, Teoh YH, Chuah HG. A Study on the Tribological Performance of Nanolubricants. Processes. 2020; 8(11):1372.)

superlattice technology. These techniques involve the deposition of multiple nano-scale layers of specific metals with superior hardness properties and chemical resistances, resulting in a novel and enhanced periodic structure. The application of these innovative coatings on industrial products aims to modify their physical properties, thereby enhancing toughness, resistance, performance, and durability[96-98].

Materials Nanocrystalline[99]

Ceramics, metals, and metal oxide nanoparticles are all included in this category. These materials are made of mostly crystallites, which are building pieces that are nanoscale in size. The atomic structure, crystallographic orientation, and chemical makeup of these building blocks can all differ. Microstructural heterogeneity is present in materials made up of nanometer-sized building pieces, such as crystallites, as well as the spaces between them (such as grain borders)[99-102].

Nano Composites[103]

Materials with a nanoscale structure that improves a product's macroscopic qualities are referred to as nanocomposites. Nanocomposites are materials made of clay, polymer, carbon, or a combination of these that include building blocks for nanoparticles[104]. These materials can be divided into two primary categories based on their nanoscale phase separation:

(a) Multi-layer Structures: These structures are frequently created by monolayer self-assembly or gas-phase deposition.

(b) Organic or Inorganic Composites: Sol-gel, cluster bridging, and nanoparticle coating inside polymer layers are three methods that can be used to create inorganic/organic composites[105].

Nano sensors to replace RFID chips on consumer products[106-108]

RFID (Radio Frequency Identification) technology utilizes uniquely identified tags that can be embedded into physical objects for position or location tracking. These tags encompass a spectrum from passive tags, powered by reader presence, to continuously signal-emitting active tags. Both types contain a microchip with a unique encoded ID and operate within specific frequency ranges according to ISO specifications for air interface (ISO-18000 2-7).

RFID technology offers several advantages, including enhanced inventory management, improved security measures, increased visibility of facilities, reduced maintenance and record-keeping time, simplified organization of assets and resources, and provision of accurate and exact information. However, there are some drawbacks associated with RFID technology. These include high operational expenses, the challenge of managing enormous volumes of data, the complexity of installation, potential problems with product tagging, sensitivity to liquids and moisture, and the constant evolution of the technology.

With the advancement of customized technologies, concerns regarding privacy and security are poised to become paramount. To safeguard privacy, customers may need to opt into programs where they receive special offers in-store via Bluetooth-enabled devices. These devices can be equipped with Java applets accessible only by the store the customer is visiting, minimizing external solicitations. Additionally, as more stores adopt high-speed internet connections, security vulnerabilities may escalate.

The IBM Privacy Research Institute collaborates with retailers and businesses to devise technologies and guidelines for preserving consumer privacy while enabling data collection. IBM asserts that addressing privacy concerns effectively will render them a non-issue if retailers prioritize customer protection.

Difficulties: Perils and Laws

Despite the field of nanotechnology's quick advancement and growing body of literature, product development and commercialization still face formidable obstacles. Concerns about the effects of some nanomaterials on human health, safety, and the environment, as well as their regulatory status, are important among these difficulties. Regulations can have a beneficial or negative impact on the responsible adoption of new technology, as Medley has pointed out. These specifications have the potential to either encourage ethical technology adoption and decision-making processes or to erect needless obstacles to innovation and use. Rules can be very helpful in spotting possible threats while preventing needless data collection, hold-ups, and higher expenses.

Morris discusses the EPA's regulatory experience with manufactured nanomaterials, emphasizing the importance of evaluating environmental sustainability and safety across their life cycle. Philbert notes challenges in predicting the safety of nanomaterials, citing the need for vigilance and careful design in the field of nanomedicine. Bergeson explores emerging governance approaches to manage the benefits and risks of nanotechnologies, highlighting the need for regulatory measures to ensure integrity and commercial predictability[109-111].

Medley proposes an integrated approach to balance regulatory oversight and technology adoption, emphasizing shared responsibility among stakeholders. Murashov and Howard discuss proactive risk mitigation strategies for nanotechnology workplaces, emphasizing the importance of anticipating, recognizing, and evaluating risks. Lin addresses the concept of "responsible development" in nanotechnology research, highlighting ethical conduct, accountability for positive and negative effects, and public engagement as essential aspects. Overall, addressing the challenges of risks and regulations in nanotechnology requires collaboration among stakeholders, proactive risk management, and ethical considerations to ensure safe and responsible development and utilization of nanotechnologies[112-113].

CONCLUSION

Several compelling factors are driving the rapid pace of technological advancement, promising a new era of innovation within the next decade. This trajectory is expected to significantly impact the manufacturing industry, introducing advanced tools and techniques that will revolutionize machine production. Anticipated developments include enhancements in mechanical properties and performance, transforming manufacturing capabilities.RFID Tracking and Nanotechnology are evolving beyond signal transmission, incorporating unique identifiers like RFID identification numbers (RIN). Real-time locator systems (RTLS) using this technology are already in use, necessitating further advancements in Nanotechnology for internal power sources and transmitters to record location data. Nanotechnology, often characterized as a transformative force, stands at the forefront of this technological revolution. Scientists and researchers are leveraging the properties of micro molecules to develop a wide array of applications. Evidence of this can be seen in improved drug delivery systems, diagnostic tools, and medical imaging, which demonstrate nanotechnology's potential to positively transform healthcare. Additionally, advancements in environmental science, such as advanced filtration systems and pollution control methods, further highlight nanotechnology's impact. With ongoing research and development, nanotechnology is poised to enhance existing systems and processes across various industries, optimizing functionality and efficiency. This evidence supports the conclusion that nanotechnology is an enabling technology with significant potential for future advancements.

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Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Author Contributions

Conceptualization: Binit Patel.; data curation: Shalin Parikh. and Pravinkumar Darji.; project administration: Binit Patel and Seshadri Nalla.; visualization: Virat Kumar Khatri. and Praneeth Ivan Joel Fnu; writing—original draft: Binit Patel. and Shalin Parikh.; writing—review and editing: Pravinkumar Darji., Seshadri Nalla. and Virat Kumar Khatri. All authors have read and agreed to the published version of the manuscript.

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