WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Comprehensive Review on Nanotechnology Innovation

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ABSTRACT:

This review paper examines current advancements in the field of nanotechnology, providing a concise overview of its application across various domains, including medicine, computing, robotics, food technology, and solar cells. The paper also explores future prospects of nanotechnology. Nanoscience investigates the unique properties of materials within the 1-100 nm scales, while nanotechnology applies these findings to develop or modify novel objects. Contemporary nanotechnology leverages advancements in forensic investigation, the food industry, and formulation and development, among others fields, to create materials with unique properties defined by their nanoscale structure.

INTRODUCTION:

Over the past decade, there has been significant research interest in developing nanotechnology through the use of nanoparticles as carriers for both small and large molecules. Various polymers have been utilized in the formulation of nanoparticles. This review highlights the most significant contribution in the filed of nanotechnology. The term 'Nano' originates from the Latin word for dwarf. Nanotechnology has been predominantly applied in scientific fields such as applied in scientific fields such as electronics, physics, and engineering for many decades. However, its potential in biomedical and pharmaceutical fields remains largely unexplored. Nanotechnology is a multidisciplinary field, representing the convergence of basic science and applied disciplines such as biophysics, molecular biology, and bioengineering. Size reduction is a fundamental operation with crucial application in pharmacy.

Major advantages of nanosizing include:

1. Increased surface area
2. Enhanced solubility
3. Increased rate of dissolution and oral bioavailability
4. Rapid onset of action
5. Reduced dosage requirements in pharmaceutical applications.

Nanoscience is the study of the unique properties of materials within the 1-100 nm range, and nanotechnology applies this research to develop or modify novel objects. The ability to manipulate structures at the atomic scale facilitates the creation of nanomaterials. These nanomaterials exhibit unique optical, electrical, and/or magnetic properties at the nanoscale, which can be utilized in fields such as electronics and medicine. Nanomaterials are distinct due to their large surface area to volume ratio.

HISTORY OF NANOTECHNOLOGY:

Even though nanotechnology seems like a budding aspect of science, its utilization by humanity isn't novel at all. The history of nanomaterials usage in construction dates back to 4500 years ago when natural asbestos nanofibers were utilized for ceramic matrices. One of the oldest, richest and progressive cultures globally, Egyptians, realized the capabilities of nanomaterials 4000 years ago. The journey of nanomaterials and nanotechnology made throughout history before millennial.

BRANCHES OF NANOTECHNOLOGY:

Nanoengineering: Precision at the Nanoscale

Nanoengineering, a specialized branch of nanotechnology, operates at the nanoscale, emphasizing the engineering over the applied science aspect of the field. The term "nanoengineering" is derived from the nano meter, a unit of measurement equating to one billionth of a meter. Two prominent techniques in nanoengineering are the scanning tunnelling microscope (STM) and molecular self-assembly. The STM enables the manipulation of structures at the atomic level, allowing the precise placement of individual atoms. In contrast, molecular self-assembly facilitates the synthesis of arbitrary DNA sequences, which can be used to create custom proteins or regular patterns of amino acids, demonstrating the profound capabilities of nanoengineering in constructing complex nanoscale structures.

Green Nanotechnology: Enhancing Environmental Sustainability

Green nanotechnology, a distinct branch of nanotechnology, focuses on enhancing the environmental sustainability of processes that traditionally have negative impacts. This branch encompasses the development and utilization of green nanoproducts to support sustainability efforts. The primary goal of green nanotechnology is to mitigate future environmental and human health risks associated with nanotechnology products and to promote the replacement of existing products with more environmentally friendly nanoproducts. Applications of green nanotechnology include solar cells, nano remediation, and water treatment, all of which demonstrate its potential to contribute significantly to environmental sustainability.

Wet Nanotechnology:

Wet nanotechnology involves manipulating large masses starting from small ones, particularly in aqueous environments. This field contrasts with the concept of nano-assemblers working in dry conditions, as proposed by W. Eric Drexler. The applications of wet nanotechnology are prominent in pharmaceuticals and biosciences, marking it as the first area where nano-assemblers achieve practical outcomes. R.A.L. Jones has extended the understanding of natural nanotechnology by integrating it into a synthetic framework known as biolistic nanotechnology. This approach leverages the principles of biomimetic nanotechnology to create trillions of nanotech robots. These robots are designed to mimic bacteria in their structural properties and can enter a person's bloodstream to perform medical treatments, such as targeting and treating cancer. Overall, wet nanotechnology represents a significant advancement in nanoscience, particularly for its potential in medical applications and biotechnological innovations.

NANOPARTICLE:

Nanoparticle are spherical, polymers particles composed of natural or artificial polymers. They range in size between 10 and 500 nm. As a consequence of their spherical shape and high surface area to volume ratio, these particles have a wide range of potential applications.

Some types of nanoparticles:

1. Liposomes
2. Dendrimers
3. Carbon Nanotubes
4. Metallic Nanoparticles
5. Quantum Dots

APPLICATION OF NANOTECHNOLOGY:

- **Forensic Investigation:**

Different scientists defined forensic science in their own point of view. In general, forensic science is a discipline of science that involves the applied knowledge of all the other basic science. The Oxford English Dictionary described forensic science as a ‘mixed science’, where various principles and methodology of other science are used to serve justice to the victims and to bring the truth behind the crime into reality. The birth of the term ‘forensic’ originated from the Latin which gave its meaning as ‘forum’ which means a place for public discussion. From this, definition for forensics science were inferred as “the method and techniques of science applied to matter involving the public”. The application of forensic science got wider in the last 30 year and now they widely used in issues related to the court of law and justice.

Application of Nanotechnology in Forensic Investigation:

Rapid advances in nanotechnology are setting new paradigms in science and technology while simultaneously raising concerns about the health risks associated with nano-objects. Recently, various types of nanoparticles have found applications in multiple areas of forensic science, including paints, inks, document security, and the development of latent fingerprints. Technological advances in forensic science have also revolutionized the characterization of particle properties, increasing the proportion of nanosized particles and expanding the variety of chemical species utilized. Forensics science encompasses a wide range of subspecialties that employ techniques adapted from the natural sciences to gather criminal or other legal evidence. The advancement of nanotechnology in forensic science involves the uses of nanoparticles to uncover critical aspects during investigations, ultimately aiding in revealing the truth.

Fingerprint Detection:

at the surface of the pores and skin fingertips, raised location of mins ridges are present known as the fingerprint ridges. those fingerprints ridges can from impressions while the fingertips come touch with any floor or items. The primary characteristics of fingerprints is that they do now not alternate over the path of time (everlasting) and every individual has unique fingerprints (individualistic, unique). this will useful resource them to get used as a tool for private identity and also allows the investigators to reconstruct the collection of activities that led up to the crime. based at the visibility of the fingerprints, they have been categorised as latent and patent fingerprints. Patent fingerprints are fingerprints that are essentially seen to bare eye, while the latent fingerprints need to be visualized with the help of chemical, bodily or optical techniques as those fingerprints are less visible to the bare eye, this form of fingerprints is the maximum commonly encountered kind at the crime scene.

Latent fingerprints are chemically composed of herbal secretion that is frequently sweat from the Apocrine and Eccrine sweat glands which are gift within the pores and skin and contaminants from the surroundings such as cosmetic, dirt, tobacco compound and so on. Ninhydrin answer and iodine or benzoflavone spray (chemical methods) had been used to develop the latent prints seen on porous surface. whereas, superglue (cyanoacrylate esters) fuming is used to developing fingerprints on non-porous surfaces. numerous nano-primarily based powders (physical methods) are also used for the improvement of latent fingerprints that are visible over the nano-pourous surface.

The fingerprints patterns are basically classified as simple arch and tented arch (arch); radial loop and ulnar loop (loop); plain whorl, central pocket loop, double loop, unintended loop and unintentional whorl (whorl). those subclassification of fingerprints are done based totally on the presence of delta, the course of entry and exit of ridges, the drift of ridges and the range of deta. In the plain arch, the ridge enters from occurs from one aspect, paperwork a wave pattern and could exit via the same aspect. in relation to the radial and ulnar loop the ridges float happens from one side and exits thru the identical aspect.

If the entry and go out of ridge is in the side of radial bone (thumb) it's far called the radial loop and if the entry and exit of ridges is in the side of ulnar bone (little finger) it's miles called the ulnar loop. the apparent whorl has two deltas and ridge have to entire at one circuit. If there is a formation of loops and deltas, they may be classified as double loop. If the sample doesn't match to any classes, they are labeled as accidental sample.

Different types of fingerprint patterns are depicted in following figure.

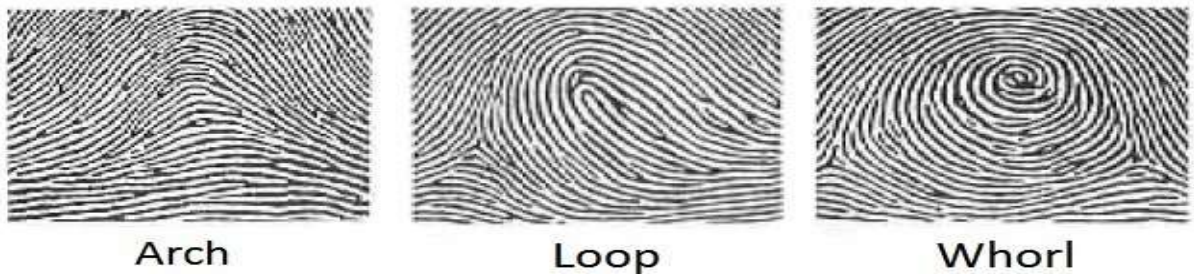

Fig.1 (Types of Fingerprinting)

Explosive Detection:

The detection of explosives remains a vital assignment for law enforcement corporations because of the complexity and high costs worried. a number of the diverse explosive compounds, trinitrotoluene (TNT) is generally encountered and has been extensively studied. conventional detection strategies, despite the fact that effective, regularly lack the sensitivity, and portability required for on-site forensic investigations. current improvements in nanotechnology offer promising solutions to those demanding situations, providing better detection talents.

In curcumin nanoparticle for TNT detection a take a look at through Panda et al. demonstrated the potential of using curcumin nanoparticles extracted from turmeric as a particularly precise fluorescent probe for TNT detection. The probe turned into capable of detecting TNT at awareness as low as 1 nano meter (nm) in aqueous answers. This massive sensitivity highlights the potential of nanotechnology-primarily based methods to surpass the competencies of traditional strategies.

Toxicology:

The synthesis of designer pills and psychotropic substances regularly entails the amendment of present drug systems. of the most frequently encountered classes of such substances are amphetamines and cathinones, which share shape similarities. figuring out these changed tablets and their toxic analogs requires sophisticated analytical strategies. Chemosensors have emerged as powerful gear for the on-web page detection and quantitative analysis of these materials.

Nanotechnology-based totally sensors are mainly useful in forensic toxicology for the detection of medicine and poisonous substances in various organic samples. these sensors may be hired for on-website checks in instances concerning capsules and alcohol, in addition to for the analysis of visceral samples and body fluids amassed at some point of forensic investigation.

formula of Ink:

Ink forensic examination includes optical exam, physical examination and chemical exam inspections create the analytical residences of the ink. lately several varieties of

Nanoparticles have been advanced for use in a new generation of anti-counterfeiting ink.

- **Forensic DNA analysis:**

The value of nanotechnology is pondered in its utility in PCR examination of pattern fragments. For, instance, if best a small amount of saliva is gathered from a crime scene, PCR will produce sufficient copies of the pattern for later analysis. using microfluidic gadgets is a recent development within the area of forensic DNA evaluation. These equipment apply at once to crime scenes, decreasing the hazard of contamination and saving research time.

- **Food industry:**

Nanotechnology offers numerous blessings to the meals enterprise, with its affect predicted to grow through the years. This swiftly growing technology impacts each aspect of the meals machine, along with cultivation, production, processing, packaging, transportation, shelf life, and the bioavailability of nutrients. the industrial packages of nanomaterials are poised to retain impacting the food enterprise because of their unique and novel residences. As a end result, human publicity to nanomaterials is increasing and will maintain to upward push. as a result, information the health influences of nanomaterials in meals is a public interest and concern. Public popularity of food and food related merchandise containing nanomaterials will hinge on their protection. therefore, organising a uniform international regulatory framework for nanotechnology in meals is vital.

- **Cultivation:**

Nanomaterials improve soil exceptional, pest control, and plant health, leading to better crop yields.

- **food production:**

superior food additives, preservatives, and flavouring created the usage of nanotechnology improve food quality and protection.

- **Processing:**

Nanotechnology permits particular manage over meals texture, colour, and dietary content.

- **Packaging:**

modern packaging and renovation techniques beautify the efficiency of meals transport.

- **Shelf lifestyles:**

Nano-encapsulation techniques protects touchy nutrients and bioactive compound, prolonging shelf life.

- **Bioavailability:**

Nano-method boom the bioavailability of nutrients and active components, improving their health blessings.

- **Human publicity:**

the industrial packages of nanomaterials are poised to keep impacting the food

enterprise because of their specific and novel homes. As a result, human publicity to

nanomaterials is increasing and will continue to upward push.

CONCLUSION:

There may be no question that nanotechnology have helped to improve the satisfactory of lifestyles of patient by using presenting a platform for advance forensic science and food industry. there is a steady push to create and develop novel nanomaterials to improve diagnosis and treatment plans for disease in a focused, cost effective and safer to use.

- Advantage of nanotechnology:

Identifying, defining and characterization of version nanomaterials.

Developing toxicity testing protocol.

Detecting and tracking exposure stage.

Assessing the impact of environment.

Development the biocompatible device.

A complete life cycle assessment is needed to extra accurately confirm the sustainability and protection of their use long term. We want a hard and fast of legal guidelines a good way to govern the way nanotech might be used in addition in future.

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