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# Nanotechnology

Govind Dukhande[1], Ashwini Bharati[2], Rupali Tasgaonkar[3]
[1, 2, 3]Bachelor of Pharmacy, Department of Pharmaceutics Yadavrao Tasgaonkar Institute of Pharmacy , Bhivpuri Road , Karjat , India

***Abstract: Nanotechnology is the exploitation of the unique properties of materials at the nanoscale. Nanotechnology has gained popularity in several industries, as it offers better-built and smarter products. The application of nanotechnology in medicine and healthcare is referred to as nanomedicine, and it has been used to combat some of the most common diseases, including cardiovascular diseases and cancer. The present review provides an overview of the recent advances of nanotechnology in the aspects of imaging and drug delivery.***

## I. INTRODUCTION

Nanotechnology can be defined as the science and engineering involved in the design, synthesis, characterization, and application of materials and devices whose smallest functional organization, in at least one dimension, is on the nanometer scale or one billionth of a meter. [7] At these scales, consideration of individual molecules and interacting groups of molecules in relation to the bulk macroscopic properties of the material or device becomes important, as it has a control over the fundamental molecular structure, which allows control over the macroscopic chemical and physical properties. [3]

## II. NANOMATERIAL

A nanomaterial is an engineered or manufactured1 material containing particles in the nanoscale range (1-1000 nm) in one or more external dimension or in an internal or surface structure2, or a material whose nanoscale particles have different properties or functions than macro-scale particles of the same material. [2]This definition also applies to incidental nanoparticles, and those not intentionally engineered, but that are manufactured by-products and incorporated in company products.[7]

## III. TYPES OF NANOPARTICLES

Several nanoparticles and nanomaterials have been investigated and approved for clinical use. Some common types of nanoparticles are discussed below. [1]

### *A. Micelles*

Micelles are amphiphilic surfactant molecules that consist of lipids and amphiphilic molecules. [1] Micelles spon- taneously aggregate and self-assemble into spherical vesicles under aqueous conditions with a hydrophilic outer monolayer and a hydrophobic core, and thus can be used to incorporate hydrophobic therapeutic agents.

[1] The unique properties of micelles allow for the enhancement of the solubility of hydro- phobic drugs, thus improving bioavailability.

[1] The diameter of micelles ranges from 10-100 nm. [1]Micelles have various appli- cations, such as drug delivery agents, imaging agents, contrast agents and therapeutic agents .[1]

### *B. Liposomes*

Liposomes are spherical vesicles with particle sizes ranging from 30 nm to several microns, that consist of lipid bilayers. [1] Liposomes can be used to incorporate hydrophilic therapeutic agents inside the aqueous phase and hydrophobic agents in the liposomal membrane layer.

[1] Liposomes are versatile; their surface characteristics can be modified with polymers, antibodies and/or proteins, enabling macromolecular drugs, including nucleic acids and crystalline metals, to be integrated into liposomes (10,11).

[1]Poly(ethylene glycol) (PEG)ylated liposomal doxorubicin (Doxil) is the first FDA-approved nanomedicine, which has been used for treatment of breast cancer, and it enhances the effective drug concentration in malignant effusions without the need to increase the overall dose . [2]

### *C. Dendrimers*

Dendrimers are macromolecules with branched repeating units expanding from a central core and consists of exterior functional groups. These functional groups can be anionic, neutral or cationic terminals, and they can be used to modify the entire structure, and/or the chemical and physical properties. Therapeutic agents can be encapsulated within the interior space of dendrimers, or attached to the surface groups, making dendrimers highly bioavailable and biodegradable. Conjugates of dendrimers with saccharides or peptides have been shown to exhibit enhanced antimicrobial, antiprion and antiviral properties with improved solubility and stability upon absorption of therapeutic drugs . [3] Polyamidoamine dendrimer-DNA complexes (called dendriplexes) have been investigated as gene delivery vectors and hold promise in facilitating successive gene expression, targeted drug delivery and improve drug efficacy . [2] dendrimers are promising particulate systems for biomedical applications, such as in imaging and drug delivery , due to their transformable properties.[4]

### *D. Carbon Nanotubes*

Carbon nanotubes are cylindrical mole- cules that consist of rolled-up sheets of a single-layer of carbon atoms (graphene). They can be single-walled or multi-walled, or composed of several concentrically interlinked nano- tubes . Due to their high external surface area, carbon nanotubes can achieve considerably high loading capacities as drug carriers. Additionally, their unique optical, mechanicaland electronic properties have made carbon tubes appealing as imaging contrast agents and biological sensors . [4]

### *E. Metallic Nanoparticles*

Metallic nanoparticles include iron oxide and gold nanoparticles. [3] Iron oxide nanoparticles consist of a magnetic core (4-5 nm) and hydrophilic polymers, such nanoparticles are composed of a gold Medicine & Drug Delivery.

With medical nanotechnology, treatment would be more efficient and precise. Instead of opening the whole body area for surgical purposes, a microscopic nanotool would spare the patient from bloody and risky surgical process. With nanotechnology in the medical field, treatment would be precise, eliminating trial-and-error drug prescription. [5]

With a single laboratory test and highly technical computers, a detailed image of the body's system and processes can be automatically spotted including the cause of the disease and its possible treatment. [6] With nanotechnology in the fields of medicine, medical malpractice would be eliminated and the side effects of taking medicines out of sheer guessing from the physicians would be avoided.[5]

The drug delivery methods used in chemotherapy has several harmful side effects because of the inaccuracy of drug deliverance at the intended target cell. Researchers at Harvard have been able to attach special RNA strands, measuring about 10 nm in diameter, to nanoparticles and fill the nanoparticles with a chemotherapy drug. [5]

These RNA strands are attracted to cancer cells. When the nanoparticle encounters a cancer cell it adheres to it and releases the drug into the cancer cell. [6] This directed method of drug delivery has great potential for treating cancer patients while producing less side harmful affect than those produced by conventional chemotherapy. [5]

With highly advanced medical equipment, potential diseases can easily be detected and prevented. [6] Since diseases can be prevented, the quality of life for mankind would be improved and lifespan would be increased.[6]atom core surrounded by negative reactive groups on the surface that can be functionalized by adding a monolayer of surface as dextran or PEG. [3] Conversely, gold moieties as ligands for active targeting (17-20). [3] Metallic nanoparticles have been used as imaging contrast agents (21), in laser-based treatment (12), as optical biosensors (12) and drug delivery vehicles (22).[4]

### *F. Quantum Dots*

Quantum dots (QDs) are fluorescent semiconductor nanocrystals (1-100 nm) and have shown potential use for several biomedical applications, such as drug delivery and cellular imaging. [3] Quantum dots possess a shell-core structure, in which the core structure is typically composed of II-VI or III-V group elements of the periodic table. Due to their distinctive optical properties and size, with high brightness and stability, quantum dots have been employed in the field of medical imaging.[3]

### *G. Reactivity and Strength Of Materials*

The nanoparticles are much more reactive than larger particles because their surface area is large as compared to volume.

[3] Studies made reveal that nanoparticles of iron can be effective in the cleanup of chemicals in groundwater because they react more efficiently to those chemicals. [3] As nanosized particles of carbon are extremely strong, bulletproof vests can be made with carbon nanotubes.[4]

### *H. Medicine & Drug Delivery*

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. Nanotechnology in imaging and diagnosis Diagnosis of a disease is one of the most crucial steps in the healthcare process. [6] All diagnoses are desired to be quick, accurate and specific to prevent 'false negative' cases. In vivo imaging is a non-invasive technique that identifies signs or symptoms within a patient's live tissues, without the need to undergo surgery.[6]

Diagnostic imaging. Imaging techniques such as X-ray, ultra- sound, computed tomography, nuclear medicine and magnetic resonance imaging are well established, and are widely used in biochemical and medical research. [6] However, these techniques can only examine changes on the tissue surface relatively late in disease progression, although they can be improved through the use of contrast and targeting agents based on nanotechnologies, to improve resolution and specificity, by indicating the diseased site at the tissue level.[6]

### *I. Nanotechnology And Cancer Treatment*

Staggering numbers of individuals suffer from cancer world- wide, highlighting the need for an accurate detection method and novel drug delivery system that is more specific, efficient and exhibits minimal side effects. [1] Anticancer treatments are often regarded as superior if the therapeutic agent can reach the specific target site without resulting in any side effects. [5] Chemical modifications of the surface of nanoparticle carriers may improve this required targeted delivery. [5] One of the best examples of modifications at the surface of nanopar- ticles is the incorporation of PEG or polyethylene oxide. [4] These modifications enhance not only the specificity of drug uptake but also the tumor-targeting ability. [4] Incorporating PEG avoids the detection of nanoparticles as foreign objects by the body's immune system, thus allowing them to circulate in the bloodstream until they reach the tumour. [1]

Additionally, the application of hydrogel in breast cancer is a prime example of this innovative technology. Herceptin is a type of monoclonal antibody used in breast cancer treatment by targeting human epidermal growth factor receptor 2 (HER2) on cancer cells. A vitamin E-based hydrogel has thus been developed that can deliver Herceptin to the target site for several weeks with just a single dose.[1]

Due to the improved retention of Herceptin within the tumour, the hydrogel-based drug delivery is more efficient than conventional subcutaneous and intravenous delivery modes, thus making it a better anti-tumour agent . [2] Nanoparticles can be modified in several ways to prolong circulation, enhance drug localisation, increase drug efficacy and potentially decrease the development of multidrug resis- tance through the use of nanotechnologies.[2]

There are several studies using FDA-approved nano drugs, such as Abraxane®, Doxil® or Genexol-PM® as adjuvants in combinatory cancer treatment. Abraxane®, a paclitaxel albumin-stabilised nanoparticle formulation (nab-paclitaxel) has been approved for the treatment of metastatic breast cancer .

[1]There are >900 ongoing clinical trials involving nab-paclitaxel as an anticancer agent, based on Clinicaltrials. gov as of August 2020. Moreover, nab-paclitaxel, in combi- nation with 5-chloro-2.4-dihydrooxypyridine, tegafur and oteracil potassium exhibited promising results when used for the treatment of HER2-negative breast cancer patients. [2] Doxorubicin, daunorubicin, paclitaxel, and vincristine are among the most extensively investigated anticancer agents in liposome-based drug formulations. [2]

### *J. Manufacturing Processes*

A major issue in nanoscale research is how scientific paradigm changes will translate into novel technological processes.[3] Nanoparticle systems, including nanoclusters, -tubes, nanostructured particles, and other three-dimensional nanostructures in the size range between 1 and about 100 nm are seen as tailored precursors for nanostructures materials and devices. [4] Particle processing (sintering, extrusion, plasma activation, selfassembling, etc.) is the most general method of preparation of nanostructured materials and devices. [4]

Nanoparticle manufacturing processes may be separated into the following groups:

1) *Nanoparticle Synthesis:* At the beginning of any investigation, one is confronted with the selection of the synthesis method, the experimental and simulation techniques to be used, and the choice of materials (metals, ceramics, polymers, organics or carbon-based, composites). [4] The main challenge is relating the final product properties and production rates to the material properties of the precursors and process conditions. [4] The product may be either homogeneous or composite nanostructured particles, with one or multi chemical species, consolidated or aerogels, including coated and doped particles. [4] The synthesis methods includes precipitation from solutions (colloids), gas condensation (aerosols), chemical, plasma, combustion, spray pyrolysis, laser ablation, supercritical fluid expansion, polymerization, mechanical attrition, molecular selfassembling, hydrodynamic cavitation, and other processes. [4] Particle synthesis at high production rates has been a major research objective in the last few years. Particle nucleation and growth mechanisms are important scientific challenges.[4]
2) *Processing And Conversion Of Nanoparticles Into Nanostructured Materials:* Nanocomponents (such as thin layers), and nanodevices (such as sensors and transistors). [4] Examples of processing methods include sintering, generation of nanostructures on surfaces, evolutionary biotechnology, and molecular selforganization techniques. [4] Research challenges include continuous particle synthesis and processing into functional nanostructures and devices.[4]
3) *Utilization Of Nanoparticles:* In order to produce or enhance a process or a phenomenon of mechanical, chemical, electrical, magnetic and biological nature. [4] Examples of the more frequently used manufacturing processes are particle contamination control, chemical vapor deposition, use of particles as agents of surface modification, filtration, mass spectroscopy, bioseparation, combustion pollution control, drug delivery and health diagnostics, and use of nanoparticles as catalysts and pigments in chemical plants. [4] The multiphase transport aspects (particle fluid and interparticle forces, rheological properties of powders, sorting, mixing, filtration, sintering, assembling, and interaction with external fields, to name a few) and transient aspects (reactions, nanostructure stability issues) have received less attention than the analysis of other physical, chemical and biological aspects. [4]
4) *Process Control And Instrumentation Aspects:* Important problems include off- and online measuring techniques for fine particles and their structures. [4] In parallel with the better-established characterization methods for particle size, shape and composition, new instruments are needed to measure particle interaction forces, their roughness, electric, magnetic and thermal properties.[4]

## IV. ADVERSE EFFECTS

Although nanotechnology has significant impact in all felids of life. It has impressive applications in almost every area of work but it also has some major disadvantages that cannot be neglected.[5] Some of its disadvantages are listed below:[5]

1) One of the biggest disadvantage that world is facing because of nanotechnology is the lack of employment in the fields of traditional farming and manufacturing and industrial sector because of the vast development in nanotechnology. [5] Nanotech devices and machines have taken place ofhumansn to work faster and more accurately which has lessened the importance of men's power in the field of practical work.[5]
2) Another big threat, which is born with the advent of nanotechnology, is the easy accessibility of atomic weapons. Nanotechnology has made these weapons more powerful and more destructive. Unauthorized, criminal bodies can reach nuclear weapons easily, and its formulation could be stolen. [4]

3) Nanotechnology has increased risk to health also, nanoparticles due to its small size can cause inhalation problems and many other fatal diseases. By just inhaling for 60 seconds in air containing nanoparticles can damage the lungs easily.[4]

## V. CONCLUSION

There is no doubt that nanotechnologies have helped to improve the quality of life of patients by providing a platform for advances in biotechnological, medicinal and pharmaceutical industries. They have also facilitated healthcare procedures, from diagnosis to therapeutic interventions andfollow-up monitoring. There is a constant push to create and develop novel nanomaterials to improve diagnosis and cures for diseases in a targeted, accurate, potent andlong-lasting manner, with the ultimate aim of making medical practices more personalized, cheaper, and safer. The prospect of nanotechnology lies in using the right nanomaterials and reducing any possible harmful effects. It is important to note that, risk evaluations are required before new nano-based products are approved for clinical and commercial use, as with any other product, to minimize any potential hazards to human health and the environment. A full life cycle evaluation is required to more accurately ascertain the sustainability and safety of their use long term.

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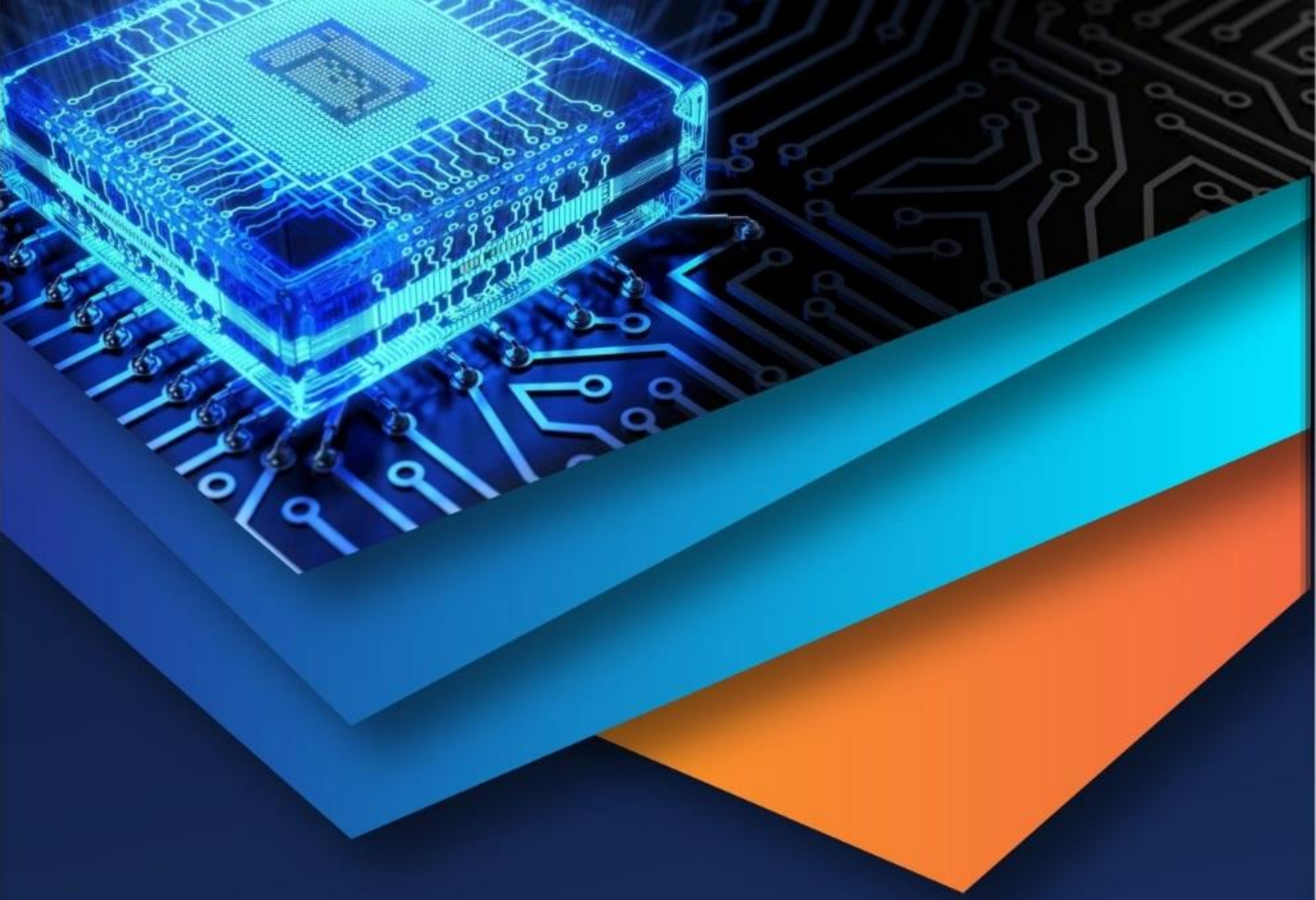


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