

NANOTECHNOLOGY AND ITS APPLICATIONS IN DRUG DELIVERY

Abstract

Nanotechnology is a newly discovered branch of science that can produce engineering-functional nanoscale devices, systems, or materials. The discipline of medicine known as nanomedicine, which uses nanotechnology applications extensively, is opening up a wide range of fascinating possibilities for improving healthcare. The nanoparticle is extremely important and can conjugate with different medications in a number of ways. In this study, we cover the use of nanotechnology in medication delivery, as well as its mechanisms, nanoparticles, and applications.

Keywords: Nanoparticles, Nanostructures, Liposomes, Dendrimers, Nanocrystals.

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I. INTRODUCTION

Nanotechnology is described by national nanotechnology programmes in the USA as "science, engineering, and technology conducted at the nanoscale, which is approximately 1 to 100 nanometers." 1nm is equal to 1×10^{-9} metres, or at the atomic and molecular levels, hence the synthesis, research design, application of functional materials at this size and manipulation falls under this category (Wanigasekera *et al.*, 2016). Nanotechnology is the name given to technology with a one billionth of a metre resolution. It involves designing, characterising, synthesising, and using structures, materials, systems and devices by adjusting their size and shape at the nanoscale scale. It is the capacity to design and use substances, structures, tools, and systems with essentially novel characteristics at the molecular, supramolecular and atomic levels. The term "nanotechnology" is used in science to define the events and processes made possible by the capacity to regulate qualities at the nanoscale, as well as the materials, technologies, and systems with structures and components displaying innovative and greatly enhanced physical, chemical, and biological features (Ochekpeet *et al.*, 2009). Nanotechnology is a newly developed branch of science that enables the development of engineering-functional nanoscale systems, devices, or materials. Nanomaterials have special mechanical, optical, magnetic, electrical, and biological capabilities. They are used in a wide variety of fields, from fundamental material research to applications in personal care. Some recently developed applications of nanotechnology include energy storage production and conversion, agriculture productivity improvement, water treatment and screening, drug delivery systems, food processing and storage, air pollution and remediation, construction, health monitoring using nanotubes and NPs, space science material production, chemical industry, information technology, textile industry, electronic consumer production, vector and pest detection and control.

Nanotechnology creates novel materials that are nanoscale, super molecular scale, or atomic scale in size. This molecular size, or one billionth of a metre, is often below 100 nm. Although nanotechnology is a relatively new topic and is important to science and technology, it has not yet reached a mature state (Janith *et al.*, 2016). Creating therapeutic substances that may be administered selectively to particular locations inside the body in order to maximise the therapeutic index is a significant and long-term objective of the pharmaceutical industry. Drugs administered systemically have a significant positive impact but can also have negative side effects. Chemotherapy for cancer has a long history of establishing a balance between effectiveness and harm. Cytotoxic substances can be very successful in killing cancer cells, but they can also harm healthy cells, which might have unfavourable and even fatal consequences (Kingsley *et al.*, 2006). The creation of nanostructures for drug delivery, such as liposomes, nano capsules, nano emulsions, solid lipid nanoparticles, dendrimers, and polymeric nanoparticles, has been extensively researched due to the advantages. The materials used to create nanostructures dictate the sort of nanostructures that are produced, and these nanostructures determine the various qualities that are produced as well as the drug release characteristics when they are combined (Ochekpeet *et al.*, 2009).

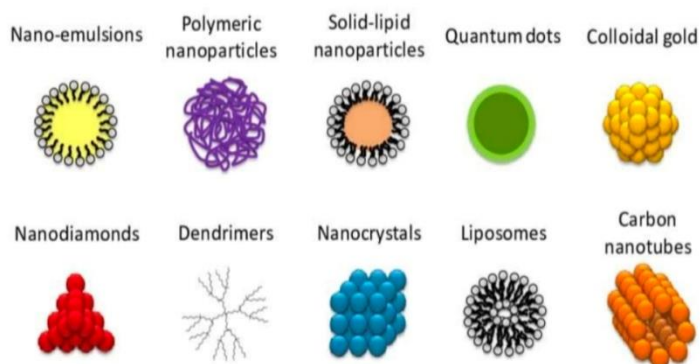
II. HISTORY OF NANOTECHNOLOGY

Many professionals in the field of nanotechnology believe that Richard Feynman, a physicist at the California Institute of Technology, laid the foundation for the field in his after-dinner address titled "There is plenty of room at the bottom" at the American Physical

Society's Winter Meeting of the West in 1959. Theorising that the whole Encyclopaedia Britannica may fit on the tip of a pin and foreseeing the advancement of knowledge at the nanoscale, Feynman is known to have investigated the prospect of controlling materials at the size of individual molecules and atoms. According to reports, Feynman suggested that atom-by-atom assembly and nanoengineering might create routes and new materials that are analogous to biological system. He described a "Nanotechnology" technical concept that involved the miniaturisation of materials and the manipulation and control of objects at a microscopic scale. He pictured a technology that built nanoobjects molecule by molecule and atom by atom utilising the natural world as a toolbox. In the aforementioned references, the terms "Nanoscale," "Nanoengineering," "Nanotechnology," and "Nano-Object" have come to represent Feynman's statement in the contemporary sense. Feynman utilised phrases like "miniaturisation," "small scale," and "small things" in his speech (Noel *et al.*, 2015). In his address, Feynman offered two prizes: one for shrinking a book's printed page and another for creating a micromotor with a specific size. McLellan developed the engine in his extra time and gave it to Feynman around two and a half months after the lecture. Based on the aforementioned, Junk and Riess concluded that Feynman was unaware of the status of modern technology because one of his rewards didn't need the use of any new equipment or methods. They said that his motive was the result of a conversation he had with Phillip Morrison, one of his colleagues. "Feynman neither entered an entirely new field, nor did he use his own mental images, nor was he sufficiently informed about the contemporary state of the art in engineering technologies," the authors said in their conclusion. Instead, he offered several intriguing concepts to encourage the growth of particular fields of science and technology. Therefore, it may be inferred that Feynman was interested in the Miniaturisation allows for the writing, storage, and retrieval (reading) of information. Terms like 4/10000, 1/16 inch, and 1/64-inch cube are microscale rather than nanoscale. Miniaturisation was not Feynman's invention, according to Cortie, who claimed that it was a point that Feynman stressed in his lecture. He said that since 1800, after John Dalton's groundbreaking investigations, there has been significant research into the behaviour of individual atoms and molecules as well as their macroscopic aggregation. Nanotechnology is not a new technology, despite the hoopla surrounding it in recent years. The Romans imitated the coloration of butterfly wings around 1600 years ago. Due to nanoparticles of gold and silver, the glass cup known as the Lycurgus cup at the British Museum appears jade green in ambient light and a striking crimson hue when a powerful light shines through it. Nanoparticles in the sky are what give sunsets their red and yellow hues, while carbon nanoparticles are used in the production of vehicle tyres. Around 2000 years ago, Indian artisans and craftspeople used nanotechnology to create weapons and durable cave paintings, and studies have revealed the presence of carbon nanoparticles on Tipu Sultan's famous sword and the Ajanta paintings, two of India's prehistoric cave paintings (Janith *et al.*, 2016).

III. NANOSTRUCTURE AND TYPES OF NANOSTRUCTURES

Nanostructures are structures that fall in between microscopic and molecular in size. At the nanoscale, microstructure is non-structural detail. It is important to distinguish between the number of dimensions in an object's volume that are on the nanoscale when characterising nanostructures. On the nanoscale, nanotextured surfaces only have one dimension, i.e., a surface thickness that ranges from 0.1 to 100 nm. On the nanoscale, nanotubes have two dimensions: length and diameter. The diameter of a nanotube ranges from 0.1 to 100 nm. Last but not least, a spherical nanoparticle has three spatial dimensions and is between 0.1 to 100 nanometers in size (Sutradhar *et al.*, 2014).



1. Liposomes: A forty-year period saw the development of liposomes. These tiny synthetic vesicles, which have uses in biology, biochemistry, medicine, food, and cosmetics, are created from phospholipids including phosphatidylcholine, phosphatidylglycerol, phosphatidylethanolamine, and phosphatidylserine. Their size ranges from 50 to 100 nm. The kind of lipid employed, its composition, how it is produced, its size, and its surface charge all affect the liposome's characteristics. Due to their capacity to stop drug degradation, lessen adverse effects, and deliver medications to the site of action, liposomes have been employed as drug carriers. On the other hand, liposomes have drawbacks such poor storage durability, limited encapsulation effectiveness, and quick leakage of medications that are water soluble when there are blood components present.

Applications for liposomes include nebulized drug delivery to the lungs, ocular drug delivery, transdermal drug delivery to improve skin permeation of drugs with high molecular weight and poor water solubility, and treatment of parasitic infections. However, solid lipid nanoparticles (SLNs) provide a good substitute because of their stability, simplicity in scaling, and economic viability. Transferosomes, ethosomes, niosomes, and marinosomes are additional vesicular structures utilised for transdermal distribution. Ethosomes are high-ethanol (up to 45%) liposomes, whereas transferosomes are made by adding surfactant molecules (edge activators) to liposomes. While marinosomes are liposomes made from a natural marine lipid extract with a high poly (unsaturated) fatty acid (PUFA) ratio, niosomes are nonionic surfactant-derived vesicles(Sridhar *et al.*, 2013).

Table 1: Several medications and treatments that involve liposomes (Wanigasekaret *al.*, 2016).

DRUG	TREATMENT
AmphotericIn B	Fungal infections
Doxorubicin	Ovarian cancer, Breast cancer
Cytarabine	Meningitis
Daunorubicin	Kaposi's sarcoma
Camptothecin	Anticancer drug
Vancomycin	Antibiotics drug

- 2. Nano-Crystals:** The medication that has to be injected into the cell is produced at the nanoscale and has the ability to operate as its own carrier. The drug particles' nano size makes them easily soluble in water. Drug particles are shrunk to the nanoscale by polymeric macromolecules and non-ionic surfactants, which also stabilise the surface. The drug's surface area increases as size decreases. Plasma concentration gradually rises as solubility dissociation increases. The incorporation of pharmaceuticals directly into the target location is made possible by the nanocrystals, which can lessen the build-up of carrier particles. Nanocrystals stabilise in aqueous dispersion without the need of stabilisers. Tumour cells can take them up quickly.

Table 2: Several drugs and treatment which uses Nanocrystals. (Janith Wanigasekare *et al.*, 2016).

DRUG	TREATMENT
Rapamycin	Immunosuppressive
Megestrol	Anti-anorexia
Fenofibrate	Hypercholesterolemia
Aprepitant	Antiemetic

IV. MECHANISM OF DRUG DELIVERY USING NANOPARTICLES

Drug bullets with the power to treat illnesses are connected to NP. The DDS based on nanotechnology solely offers proper medication delivery to target areas without any modifications being made to the parent therapeutic particle. To be therapeutically effective, the medications either needed certain pH conditions, were not water soluble, or required large drug concentrations. Drug The three major techniques used to attach drugs to polymers are non-covalent complexation, encapsulation, and conjugation to polymeric carriers through suitable linkers (Noel *et al.*, 2015). The size of the polymer-drug combination has a significant effect and should be controlled by altering the polymer's molecular weight. Drug permeability, hydrophobicity, and solubility are altered by drug-polymer attachment. The matrix density affects the medication loading capability of the NPs. By reducing solubility, increasing ionic interactions between the drug and matrix, and maximising drug absorption, the drug loading capacity can be increased. Linkers form a covalent bond between the drug and the polymer, and they are pH- or enzyme-sensitive. Immune cells have the ability to recognise and eliminate the medication bound to NP. The particle surface is embellished with biodegradable, hydrophilic copolymers to address this issue and enable prolonged particle circulation (Uwe *et al.*, 2008).

The pace at which a medicine is released may be regulated by its degradability. For surface decoration, polyglycolic acid (PGA), poly-lactic acid (PLA), and related co-polymers are frequently utilised. Due to their capacity to concentrate nucleic acid into nanoscale polyplexes with a protective and biocompatible PEG shell, PEG-copolymers are of increased interest. PEG can also delay the adsorption of serum proteins, extending the time that particles are circulated throughout the body and lowering toxicity. To increase the specificity of drug delivery to the target region, ligands were additionally added to the NP surface (Patel *et al.*, 2013).

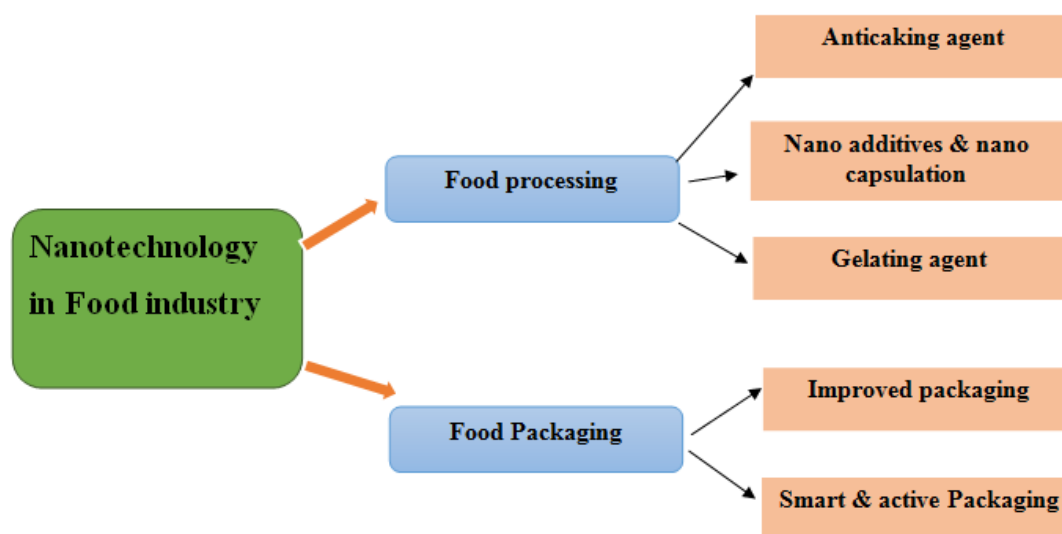
Proteins, peptides, sugars, lipoproteins, charged compounds, and antibodies. As aptamers, nucleic acid ligands such as DNA, siRNA, and mRNA have a high affinity and specificity for their target. NP may enter the body by several routes, including oral, intravenous, arterial, cutaneous, transdermal, and inhalation. Drug-NP conjugate is injected into the bloodstream and can be absorbed by the cells and tissues. Drugs are transported through the bloodstream by dissolving, scattering, and then reaching the target location. While conventional DDS provide drugs to every cell in the body, nanotechnology-based DDS deliver drugs to the target spot through a process called ligand attraction. The drug-NP conjugate should be able to deliver medication to the target location without gastrointestinal tract degradation and without lowering medication activity or volume. Second, it should target cells while sparing surrounding cells from damage and minimising adverse effects. There are two different kinds of medication delivery to the cells. Drugs are diffused to the extracellular matrix and then diffused to the cell in passive targeting (A). It improves the effect of NP's cellular retention and permeability. Vesicles within a tumour are incredibly disorganised and include pores. Therefore, widen the gap junction that exists between endothelial cells. These tumour site holes make it easier for NP to enter tumour cells than normal cells. All tumours and normal cells cannot be passively targeted because some tumour cells are lack of pores(Quan *et al.*,2015).

Drug leakage from NP reduces when reservoir concentration falls. B) Active targeting: Aptamers, antibodies, and affinity ligands bind to a particular receptor on the cell surface. Nanocarriers attach to the target cell by interacting with receptors on the cell surface that are expressed in response to ligands. Compared to other cells, tumour cells express these receptors more strongly. The ligands that coat the NP surface can connect to the particular receptors on the surface of the targeted cell through biorecognition. By means of receptor-mediated endocytosis, the NPs are taken up by the target cells. This endocytotic vesicle contains NPs and is produced when a section of the plasma membrane invaginates. By using this technique, thousands of NPs can readily penetrate the cell. NPs mature into endosomes inside the cell. Then, endosomes combine to produce massive endosomes, also known as lysosomes. Finally, by degrading the polymeric NP shell, medicinal medicines can release in reaction to enzymes or an acidic pH in a controlled way. There are several techniques to controllably release a medicine at a specific site: i) Polymers are biodegradable and disintegrate in a controlled manner to release the drug; ii) The preparation process can change the polymer's pores. Therefore, drug diffusion might happen quickly or gradually. iii) By adjusting size, the fusion distance and the surface area of the NP may be changed. A significant factor is the size of the NP; smaller size equals more surface area. Drug release and dissolution occur more quickly, and this may be controlled by altering NP size. The matrix releases the medicines by diffusion, swell, erosion, or disintegration. Osmotic pressure, mechanical pumping, and electrokinetic transport are used to regulate the drug's release. By adjusting the parameters of nano-fluidic devices, it is possible to achieve constant medication release (Janith *et al.*,2016).

V. APPLICATIONS OF NANOTECHNOLOGY

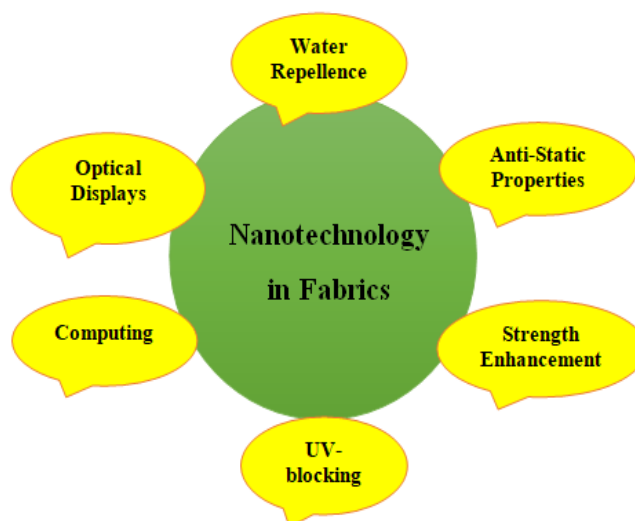
1. Nanotechnology in Food Industry: Numerous scientific and industrial fields, including the food sector, have been significantly altered by nanotechnology. With the growing demand for nanoparticle applications in a variety of areas of food science and food microbiology, such as food processing, food packaging, functional food development, food safety, the detection of foodborne pathogens, and the extension of food and/or food

product shelf lives, applications of nanotechnology have emerged. Food nanostructured ingredients and food nano sensing are the two primary categories in which the uses of nanotechnology in the food industry may be categorised. Ingredients with food nanostructures cover a wide range of applications, including packaging and food processing. These nanostructures can be used as food additives, carriers for intelligent nutrient delivery, anti-caking agents, antimicrobial agents, fillers to improve the mechanical strength and durability of the packaging material, etc. in the food processing industry. In contrast, food nano sensing can be used to improve the evaluation of food quality and safety. When food is preserved using nanomaterials, the meal may be shielded from lipids, gases, off tastes, and aromas. The nutritional value of food is increased and maintained by these agents (Treptiet *al.*, 2017).



2. Nanotechnology in Fabrics: In order to enhance performance, manufacturers are altering the characteristics of well-known materials by including nanoscale components. To create clothing that is resistant to stains and water, some garment producers, for instance, weave nanoscale whiskers into the fabric.

- In the manufacturing of spill- and dirt-resistant, microbial- and bacterial-resistant materials.
- In the manufacture of bulletproof vests. Commercial nanotechnology applications also began to emerge in the early 2000s, but they were confined to large-scale uses of nanoparticles.
- Silver nano platform for transparent sunscreens based on nanoparticles, antibacterial silver nanoparticles, and carbon nanotubes for stain-resistant fabrics.



- 3. Nanotechnology in Mobile:** A nanotechnology concept device was developed by the University of Cambridge and Nokia Research Centre (NRC) in the UK. The Morph's strong hydrophobicity will make it very dirt-repellent. Its surface will be covered in photovoltaic nanowire grass, allowing it to recharge itself from nearby light sources. Nanoscale electronics also enable stretching. Nokia imagines a nanoscale fibre mesh that will let us to bend, stretch, and fold our mobile devices into any configuration we can capable of.
- 4. Nanotechnology in Electronics:** Nanowire-based flat panel displays are more flexible and thinner than conventional flat panel displays. The process of making chips with nanolithography. Nanowires are built into transistors on glass or thin, flexible plastic sheets. E-paper, display-equipped eyewear, and windscreen maps for cars.
- 5. Nanotechnology in Computers:** Computer transistors made of silicon could be replaced with carbon nanotube transistors. A carbon nanotube is a single-atom-thick, hollow carbon molecule with a diameter of around one nanometer. Due to its low energy consumption and minimal heat emission, nanorods are a developing technology in the field of display technology. The size of microprocessors is shrinking. According to scientists at North Carolina State University, magnetic nanodots are expanding arrays of magnetic nanoparticles.
- 6. 5nanotechnology in Agriculture:** Agrochemical nano formulations for administering pesticides and fertilisers to enhance crops, for example, have the potential to raise agricultural output. Applications of nano sensors in crop protection for disease and pesticide residue detection. employing nanotechnology for plant genetic engineering. disease detection in plants Production of poultry, animal breeding, and animal health are all crucial. post-harvest management. Future agricultural output enhancement may be achieved while preserving soil and water by using precision farming practises.

One of the uses of nanotechnology is the transfer of DNA in plants to produce biomass for fuel. Nanoparticles and nano capsules are two examples of tools used in agriculture for the diagnosis and treatment of plant diseases.

7. Nanotechnology in Cancer Treatment: Nephrotoxicity, neurotoxicity, cardiotoxicity, and multiple drug resistance (MDR) lower drug concentration at target locations and cause poor accumulation when a treatment is delivered to tumour cells typically. Increased efflux pumps in cell membranes, such P-glycoprotein, are mostly to blame for MDR. Drugs can be passed by Paclitaxel-loaded NP without affecting MDR. The implementation of an NP-based medication delivery system helps to solve these issues. To quickly deliver nutrition and oxygen, the tumour sites rapidly create new blood vessels. Since the freshly produced vesicles are flawed and have leaky vasculature, NP can diffuse through them. As the need for energy rises, glycolysis happens. In the end, an acidic environment is created, and the manipulation of pH to release drugs is advantageous (Wanigasekara *et al.*, 2016).

Nano particles, especially in imaging, can be very useful in cancer because of their tiny size. Magnetic resonance imaging may be used with nanoparticles like quantum dots that have quantum confinement qualities like size-tunable light emission to create outstanding pictures of tumour spots. Nanoparticles are significantly brighter than organic colours and only require one light source to be excited. Therefore, using fluorescent quantum dots as contrast media might result in a stronger contrast image and at a lesser cost than using organic dyes. But very hazardous materials are typically used to make quantum dots.

Due to their very high surface area to volume ratio, nanoparticles can attach a variety of functional groups, which then bind to specific tumour cells. Furthermore, because tumours lack a functional lymphatic drainage system, nanoparticles of a size of 10 to 100 nm might preferentially aggregate at tumour locations. Future cancer treatments may make use of multifunctional nanoparticles that can photograph, identify, and then treat tumours. With the use of radio waves that only heat the nanoparticles and the nearby (cancerous) cells, Kanzius RF treatment "cooks" tumours within the body by attaching small nanoparticles to cancer cells. A single drop of a patient's blood may be used to create sensor test chips that can identify proteins and other indicators left behind by cancer cells. This allows for the early detection and diagnosis of cancer.

- Three facts serve as the foundation for medication delivery via nanotechnology.
- Drugs must be well encapsulated, successfully delivered to the intended area of the body, and
- The medicine was successfully released there. Prof. Jennifer at Rice University employed nanoparticles with a diameter of 120 nm that were coated in gold to eradicate cancerous tumours in mice. By attaching antibodies or peptides to the surface of the nano shells, it is possible to direct these nano shells to bind to malignant cells. An infrared laser is used to target the tumour, sufficiently heating the gold to destroy the cancer cells.

Because cadmium selenide nanoparticles glow under UV light, they are utilised to identify malignant tumours in the form of quantum dots. When the surgeon injects these quantum dots into cancerous tumours, the glowing tumour can be readily removed since the surgeon can see it. In cancer photodynamic treatment, nanoparticles are utilised. These particles are injected within the body's tumour and exposed to photo light from the outside. The particle takes in light, and if it's made of metal, the light's energy causes it to

heat up. Light causes the production of highly energetic oxygen molecules that chemically combine with tumour cells and kill them without interacting with healthy body cells. The use of photodynamic therapy as a non-invasive method of treating tumours has grown in prominence (Umama *et al.*, 2018).

8. Nano X-Ray Nano-Particle Therapy:

- X-rays are capable of hydrolyzing water molecules to form free radicals during conventional radiotherapy. In the end, it can harm the DNA and other molecular components of both healthy and tumour cells. Nano X-ray NP is suspended in water and features a self-protecting coating to reduce unintended interactions. It is injected into cancer patients, and by particular identification, it exclusively attaches to tumour cells. When compared to water, nano x-ray NP attracts X-ray more quickly. To destroy just tumours and spare healthy cells, it can disrupt both double-stranded and single-stranded DNA in tumour cells.
- The surface of the NPs is adorned with PEG and target ligands to enable drug administration to the target spot without hurting healthy cells. The NPs are connected with extremely toxic cancer medicines like Doxorubin.
- Au NP, used in photothermal treatment, has optical characteristics that allow it to absorb light that is close to the ultraviolet. The viability of cells is lost when the temperature of the cell rises over 42°C. The NP heats up after the body has been exposed to radiation or a magnetic field, which causes the radiation of tumour cells. Metal particles that attach to the cysteine residues in heparin-binding growth factor can decrease the phosphorylation of proteins involved in the angiogenesis process.
- To treat oral tumours and overcome limited solubility, permeability, and poor bio-availability, medications like cetureimab and fluorouracils are linked with liposomes, hydrogels, and crystals.
- The majority of applications are still in the research stage, are being tested on animals, or are just concepts. By using red cell membrane instead of PEG to coat the surface of NP, researchers are attempting to;
 - Lengthen the time that blood circulates through them.
 - Gold nanoparticles can be used in platinum cancer therapy to lessen adverse effects.
 - Create various NPs with various ligands, drug particles, and morphologies to treat tumours.
 - Making advantage of photosensitive substances that build up in tumours and make blood vesicles more porous so that NPs may enter them more readily.
 - Use RNA to attach to skin tumours.
 - Spherical NP coated with si.RNA for the treatment of lung cancer.
 - Antitumor monoclonal antibodies and vaccines are available.

9. Nanotechnology in Heart Diseases: This is currently being studied. An artery's damaged areas can be reconnected to healthy artery walls using the protein NP, which is also used to dissolve blood clots. To transport proteins to the proper location in arteries, NPs are being directed under a magnetic field.

Patients with diabetes: developed NP with insulin connected to matrix. When blood glucose levels rise, the enzymes on NP trigger the release of insulin, which in turn controls blood glucose levels over several days. Timolol maleate was used to treat glaucoma in nano-diamonds placed in contact lenses.

10. Nanotechnology in Tuberculosis (TB): TB treatment needed frequent and ongoing medication administration to the cells. The NP was coated with PE G and connected with medications including rifampin (RMP), isoniazid (INH), and pyrazinamide (PZA) to supply pharmaceuticals to TB cells in a long-lasting way. In order to treat TB, researchers are attempting to increase medication bioavailability and decrease dose frequency.

11. Nanotechnology in Bone Diseases: The calcium-phosphate-based NP is used to administer medications to treat bone disorders without harming bone tissues. Utilising medications such as bisphosphonates, arthritis, osteoarthritis, osteosarcoma, and metabolic bone cancer are treated. Bone regeneration is successful using silica and magnetic NP.

12. Nanotechnology in Central Nerve System Diseases: Treatment of neurodegenerative illnesses is one of nanotechnology's most significant uses. Numerous nano carriers, including dendrimers, nano gels, nano emulsions, liposomes, polymeric nano particles, solid lipid nano particles, and nano suspensions, have been investigated for the delivery of CNS medications. Early preclinical success for the treatment of the many CNS disorders listed below is achievable thanks to endocytosis and/or transcytosis, which have an impact on the transportation of these nanomedicines across diverse in vitro and in vivo BBB models (Umama *et al.*, 2018). Drugs for brain tumours, Alzheimer's disease, inborn metabolic defects such as lysosomal storage disorder, viral infections, and ageing, among other conditions, can be delivered with NP since it can pass the blood-brain barrier (BBB). The BBB, blood-cerebrospinal fluid barrier, or other specialised central nervous system barriers are impediments to the passage of the majority of therapeutic particles. The BBB is impermeable to all but a limited subset of medications or compounds with strong lipid solubility and low molecular mass. NP has a strong affinity and can move drugs through the BBB with precision. Some molecules are transported throughout a variety of organs, such as growth factors and insulin (Wanigasekara *et al.*, 2016).

Examples

- Alzheimer's disease
- Alzheimer's disease
- HIV encephalopathy
- Acute ischemic stroke
- Brain tumors

13. Nanotechnology in Ophthalmology: This young field is anticipated to produce treatments for ocular conditions. It has been successfully created a unique nanoscale-dispersed eye ointment (NDEO) for the treatment of severe evaporative dry eye. Medium-chain triglycerides (MCT) were combined with the excipient's petrolatum and lanolin, which are often included in eye ointments, to make semisolid lipids. Both phases were then dispersed in polyvinyl pyrrolidone solution to create nano dispersion. According to a transmission electron microscopy, the MCT nano emulsion had a mean particle size of around 100 nm and included the ointment matrix. Higher ointment matrix

concentrations in the NDEO formulations compared to a commercial product showed a tendency of positive connection with the therapeutic effects of NDEO, which were examined and showed therapeutic improvement.

Recent studies demonstrate the use of various nanoparticulate systems in the field of ocular drug delivery, including micro emulsions, nanosuspensions, nanoparticles, liposomes, noisomes, dendrimers, and cyclodextrins. They also illustrate how emerging nanotechnology applications, including nanomedicine, nano diagnostics, and nanoimaging, can be used to push the boundaries of ocular drug delivery and therapy (Umama *et al.*, 2018). Other ongoing researches:

- In order to shield astronauts from the effects of radiation, NASA created bio-capsules.
- Make an effort to introduce antigens into the body to boost defences.
- Enhance dental implants by coating the implant matrix with nanotubes.
- To increase the period of circulation, attempt to bind RNA to the NP surface.

14. Nanotechnology in Covid-19 Pandemic: A viral infectious illness that started in China at the end of 2019 quickly spread around the globe. On March 11, 2020, the World Health Organisation (WHO) formally announced that the coronavirus epidemic was evolving into a pandemic. The SARS-CoV-2 new coronavirus and COVID-19 illness were given such names by the WHO. The Coronaviridae family of viruses, which comprises the genera Alphacoronavirus, Betacoronavirus, Gammacoronavirus, and Deltacoronavirus, includes the RNA viruses known as Coronaviruses (CoVs), which range in size from 27 to 32 kb. Because all CoV particles include spikes that resemble crowns, the virus is also known as the "corona" virus. The CoV particles range in size from 80 to 160 nm and are pleomorphic. It is known that CoVs may infect people and a variety of animals. Bronchitis, pneumonia, and the common cold are only a few of the respiratory illnesses caused by human coronaviruses (HCoVs), a prominent category of CoVs. HCoVs have one of the highest rates of genomic nucleotide recombination, making them the viruses that evolve the fastest at the moment.

Researchers in the field of nanomedicine have been investigating the relationship between high infectivity and the capacity of various nanosystems and viral vectors to deliver genes. In order to create delivery methods that may be applied in a number of disciplines, nanomedical researchers have researched the molecular processes of vectors. Since viruses and nanoparticles (NPs) operate at the same size, developing vaccines and performing immune engineering rely heavily on this strategy. Nanomedicine may be the ideal substitute for cutting-edge technology for the production of vaccines since NPs are instruments that may mimic the structural and functional characteristics of viruses. From the perspective of vaccine technology development, the present—when SARS-CoV-2 is a severe threat on a worldwide scale—is critical, and nanotechnology and nanomedicine are provided as unique therapeutic technologies and procedures that can have an influence on the clinical setting.

VI. FUTURE PROSPECTIVES

In the future, nanotechnology-based DDS may be improved to treat diseases by BBB delivery of proteins, antibiotics, vaccines, and vesicles, gene therapy, radiation, and

anticancer treatment. Scientists may create drug loading, targeting, transporting, releasing, interaction with barriers, low toxicity, and safe settings if they research the mechanism and destiny of NP-drugs using animal models prior to human use. The ability of medications to treat bone disorders and promote bone regeneration when delivered to delicate organelles like the nucleus is improving. It may be possible to create multifunctional NPs that can simultaneously monitor and treat patients while also identifying malignant cells, delivering many medications at once, visualising the location using imaging agents, and eliminating cancer cells with the fewest possible adverse effects.

This particle can be improved to treat conditions like HIV and cancer, and similar nanoparticles can be created as robots to do surgeries like those for heart conditions. When combined with computer programming, nanoparticles can autonomously control human homeostasis, including blood glucose and calcium levels. In the future, we can enhance these NPs to serve as strong defences against foreign particles in the body.

VII. CONCLUSION

Nano materials are used as a promising tool for the advancement of drug and gene delivery, biomedical imaging and diagnostic biosensors, analytical, detection, and therapeutic purposes and procedures, such as targeting cancer, drug delivery, improving cell-material interactions, scaffolds for tissue engineering, and gene delivery systems, and offer novel opportunities in the fight against incurable diseases because of their increased surface area and nano scale effects. Nanomedicine has the potential to significantly expand several different industries, including medicine, communications, genetics, and robotics. Miniaturisation appears to offer more affordable and quickly operating mechanical, chemical, and biological components.

In the upcoming years, nanotechnology will play a significant role in the future of medicine by presenting ground-breaking opportunities for early disease detection, diagnostic and therapeutic procedures to improve health and enhance human physical capabilities, and enabling precise and effective therapy specifically tailored to patient needs. For prevalent viral illnesses such as IAV and IBV, EBOV, HIV-1 and 2, HSV-1 and 2, HBV and HCV, and HuNoV, several therapies utilising nanotechnology have been created and made available for purchase. The development of SARS-CoV-2 therapies and vaccines may advance as a result of the cumulative advances in these virus-fighting nanotechnologies. This shift in the research and development paradigm may have acceptable alternatives in nanotechnology and nanomedicine.

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