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NANOTECHNOLOGY AND ITS APPLICATION IN PHARMACEUTICAL FIELD: - A REVIEW

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ABSTRACT

Exploiting the special characteristics of materials at the nanoscale is known as nanotechnology. Due of the improved quality and smarter goods that nanotechnology offers, it has becoming more popular across a variety of industries. The study of incredibly small structures, ranging in size from 0.1 to 100 nm, is known as nanotechnology. A relatively recent area of science and technology is nanomedicine. Nanomedicine is the use of nanotechnology in healthcare and medicine, and it has been utilized to treat some of the most widespread illnesses, such as cancer and cardiovascular conditions. An overviewof recent developments in nanotechnology in the areas of imaging and medication delivery is given in the current article.

Treatment of neurodegenerative diseases like Parkinson's and Alzheimer's is made easier by advances in nanotechnology.

This article discusses applications of nanotechnology in the treatment of tuberculosis, as well as the clinical use of nanotechnology in operative dentistry, ophthalmology, surgery, visualization, tissue engineering, antibiotic resistance, and immune response. Pharmaceuticals made of nanomaterials can be used toidentify diseases considerably early.

Keywords*: - nanotechnology, nanomedicine, imaging, drug delivery system, health concerns*

1. INTRODUCTION

The twentieth century has undergone a transformation thanks to advancementsin nanotechnology and its applicability to the fields of drugs and medicine. The study of exceedingly small structures is known as nanotechnology. Greek word "nano" means "dwarf" and is used as the prefix. Nano refers to a very small or minuscule size. By manipulating individual atoms, molecules, or compounds into structures, nanotechnology creates materials and gadgets with unique qualities.In nanotechnology, work is done either from the bottom up, which more closelymimics chemistry and biology, or from the top down, which entails shrinking the size of huge structures to the tiniest structures, such as photonics applications in nano electronics.

Nanotechnology is the use of such research to make or alter novel items. Science is the study of the special properties of materials between 1-100 nm. Nanomaterials can be produced thanks to the atomic-scale structure manipulation (1-3). Nanomaterials can be employed in a variety of applications, including electronics and medical, since they exhibit special optical, electrical, and/or magnetic capabilities at the nanoscale. Because they offer a high surface area to volume ratio, nanomaterials are exceptional. Nanomaterials are regulated by the principles of quantum mechanics rather than the classical laws of physics and chemistry, in contrast to conventional large-scale manufactured objects and systems. Nanotechnology, in its simplest form, is the creation of usable items and functional systems at the atomic or molecular size.

Because they provide I better-built, ii) safer and cleaner, iii) longer-lasting, and iv) smarter goods for the medical, communications, daily life, agricultural, and other industries, nanotechnologies have had a substantial impact on practicallyall industries and areas of society. There are two main categories of hownanoparticles are used in common items. First, by incorporating some of its special features into a pre-existing product, nanomaterials can enhance the composite products' overall performance. Otherwise, due to their unique features, nanomaterials like nanoparticles and nanocrystals can be used directlyto produce sophisticated devices with high power. Nearly all industrial areas may be impacted by the advantages of nanomaterials in the future.

2. NANOTECHNOLOGY IN MEDICINE AND HEALTHCARE

The word "nanomedicine" is used to describe the use of nanotechnologies in healthcare and medicine. In particular, diseases can be prevented, detected, monitored, and treated using nanoscale technologies and nano-enabled methods. Nanotechnologies have the potential to significantly advance the fieldof medicine, including in imaging and diagnostic tools, drug delivery systems, tissue-engineered constructs, implants, and pharmaceutical

therapeutics. They have also advanced the treatment of a number of diseases, such as diabetes, bacterial and viral infections, cancer, cardiovascular diseases, and musculoskeletal conditions.

3. CLASSIFICATION OF NANO MATERIALS

Nano materials can be classified dimension wise into followingcategories:

Classification Examples:

- Nano rods, nano wires have dimension less than 100 nm.
- Tubes, fibers, platelets have dimensions less than 100 nm.
- Particles, quantum dots, hollow spheres have 0 or 3 Dimensions < 100 nm.

On the basis of phase composition, nano materials in different phases can beclassified as,

- The nano material is called single phase solids. Crystalline, amorphous particles and layers are included in this class.
- Matrix composites, coated particles are included in multi-phase solids.
- Multi-phase systems of nano material include colloids, aero gels, Ferro fluids, etc.

4. NANOTECHNOLOGY IN IMAGING AND DIAGNOSIS

One of the most important steps in the medical procedure is the diagnosis of a condition. All diagnosis should be made as quickly, precisely, and specifically as possible to avoid "false negative" cases. Using a non-invasive method called in vivo imaging, symptoms or signals can be found in a patient's live tissues without requiring surgery. Biological markers that may identify changes in tissues at the cellular level are a previous advancement in diagnostic imaging techniques. Utilizing a biological marker is intended to identify diseases or their symptoms, acting as a tool for early diagnosis. It is noteworthy that some of these highly accurate molecular imaging agents have been created using nanotechnologies. Imaging is crucial not only for diagnosing diseases but also for researching controlled medication releases, assessing drug distribution in the body, and closely monitoring the effectiveness of therapies. With the possibility of trackingthe movement of medications throughout the body and by releasing the drug asneeded, potential drug toxicity can be decreased.

Diagnostic imaging Research in biochemistry and medicine frequently usesimaging techniques like X-rays, ultrasounds, computed tomography, nuclear medicine, and magnetic resonance imaging. Though they can be enhanced by the use of contrast and targeting agents based on nanotechnologies to improveresolution and specificity by identifying the diseased spot at the tissue level, these techniques can only analyses alterations on the tissue surface very late in disease progression. The majority of the contrast agents employed in medical imaging today are tiny molecules with a non-specific distribution and a quick metabolism, which raises the possibility of unfavorable toxic side effects. Since nanomaterials have reduced toxicity and better permeability and retention effects in tissues, this is the area of medicine where nanotechnologies have hadthe biggest impact by helping to design more potent contrast agents for practically all imaging procedures. The biodistribution, blood circulation half- life, cellular absorption, tissue penetration, and targeting of nanoparticles are all greatly influenced by their size.

5. MANUFACTURING APPROACHES

The two main methods for obtaining nanomaterials are the bottom-up method and the top-down method. Single-molecule-based bottom-up produced components are held together by covalent forces that are much stronger than those found in macro-scale components. Devices constructed from the ground up might store an enormous quantity of data. AFM, liquid phase techniques based on inverse micelles, solgel processing, chemical vapour deposition (CVD),laser pyrolysis, and molecular self-assembly are a few examples of bottom up approaches used in the production of nanoscale materials.

Due to the constraints of our current manufacturing procedures, very advancednanodevices have not yet been produced. Top manufacturing involves the creation of parts using techniques including cutting, carving, and moulding. Forthe production of nanoscale materials, top-down methods such as

electroplating, physical vapour deposition, hydrothermal process, nanolithography, and laser ablation are used.

According to the goal material being created, which can range from nanomedicine to nanoconcrete via nanoelectronics, every element on the periodic table can be used in nanotechnology. We can create nanoscale buildingblocks with control over their size, composition, and other characteristics thanks to nanotechnology. The further assembly of materials into larger structures withintended qualities will revolutionise the fabrication of materials. Metals, polymers, ceramics, and other materials can be precisely shaped without the need for machining.

Chemical catalysis can benefit from nanotechnology because of the incredibly high surface to volume ratio. Fuel cells, catalytic converters, and photocatalyticdevices are just a few of the different catalytic processes in which nanoparticlesare used. Additionally, it is crucial for the manufacture of chemicals. Zeolites arereadily available in unlimited commercial quantities, which has led to a revolution in catalysis today.

6. APPLICATIONS OF NANOTECHNOLOGY

The different fields that find potential applications of nanotechnologyare as follows:

(a) Health and Medicine
(b) Electronics
(c) Transportation
(d) Energy and Environment
(e) Space exploration

7. MEDICAL USE OF NANO MATERIALS

A relatively recent area of science and technology is nanomedicine.

Nanotechnology broadens the scope of research and application by interacting with biological molecules at the nanoscale. It is possible to comprehend how nano gadgets interact with bio molecules both inside of human cells and in the extracellular medium. Operation at the nanoscale enables the use of physical characteristics not seen at the microscale, such as the volume/surface ratio.

The use of gold nanoshells to help diagnose and treat cancer and the use of liposomes as vaccine adjuvants and drug delivery vehicles are two types of nanomedicine that have already been tested in mice and are awaiting human trials. Similar to this, nanomedicine has also been effectively applied in rats for drug detoxification. Smaller gadgets used in medicine are less intrusive, more likely to be implanted inside the body, and have significantly faster biochemicalreaction times. Nanotechnology-based drug delivery methods are quicker and more precise than conventional methods.

8. DRUG DELIVERY

Nanoparticles are employed in nanotechnology to deliver drugs to precise sites.As the active substance is exclusively deposited in the morbid zone, this procedure uses the required drug dose and considerably reduces adverse effects. This extremely selective method can lower expenditures and ease patients' suffering. As a result, several nanoparticles, including dendrimers and nanoporous materials, find use. For medication encapsulation, block co-polymer-derived micelles are employed. They deliver tiny medication molecules where they are needed. For the active release of medications, nano electromechanical systems are also used. Applications for iron nanoparticles orgold shells in the therapy of cancer are significant. A tailored medication lowersdrug consumption and medical costs, making patient care more affordable.

Nanoparticles or molecules are employed in nanomedicines to deliver drugs and can increase the bioavailability of certain drugs. For optimising bioavailability over a period of time and at specific locations in the body molecular targeting isnow carried out via nanoengineered devices for instance, nanorobots. The molecules deliver what is intended is carried out with cellular accuracy. An additional field is in vivo imaging. where in vivo imaging techniques and devices made of nanomaterials are being created. Using nanoparticle pictures from ultrasound and MRI, nanoparticle imaging as a comparison, particles are employed. For the purpose of efficiently treating illnesses and diseases like cancer, nanoengineered materials are being produced. Self-assembling biocompatible nano devices that can detect malignant cells and automatically diagnose the condition, treat it, and produce reports are now possible because to advances in nanotechnology.

By using lipid and polymer-based nanoparticles in drug delivery systems that are properly designed, it is possible to enhance the pharmacological and therapeutic effects of medications. The capacity of drug delivery systems to change the pharmacokinetics and biodistribution of the drug is one of their strongest points. The usage of nanoparticles, which are made to evade the body's defence processes, can enhance medicine delivery. Drug delivery systems that can penetrate cell membranes and enter the cytoplasm of cells are currently being developed in an effort to increase efficacy.

9. THE APPLICATIONS OF NANO PARTICLES IN DRUG DELIVERY

Abraxane is albumin-bound paclitaxel, a nanoparticle used to treat non-small- cell lung cancer and breast cancer (NSCLC). In a mouse model study conducted at Rice University and the University of Texas MD Anderson Cancer Center, nanoparticles were employed to deliver the medicine with increased effectiveness for treating head and neck cancer. The disclosed therapy makes use of Cremophor EL, which enables intravenous delivery of the hydrophobic paclitaxel. As a result of the poisonous Cremophor's side effects being reduced and the drug's targeting being significantly enhanced, a lower dose of the dangerous paclitaxel is required.

Doxorubicin was administered to breast cancer cells via a nanoparticle chain in a mouse research at Case Western Reserve University. The researchers chemically connected one doxorubicin-loaded liposome to three magnetic, iron-oxide nanospheres to create a chain of nanoparticles that was 100 nm long. After the nano chains had entered the tumour, magnetic nanoparticles were made to vibrate by creating a radiofrequency field. This caused the liposome tobreak, releasing the medication in its free form, which was then dispersed throughout the tumour. Nanotechnology was more effective at stopping tumour growth than the traditional doxorubicin treatment, and it caused less harm to healthy cells because far lower dosages of doxorubicin were utilised.

According to MIT scientists, polyethylene glycol (PEG) nanoparticles with an antibiotic payload at their core were employed to target bacterial illness inside the body more precisely. Antibiotic-resistant bacteria are destroyed by nano delivery of particles that include a sub-layer of pH-sensitive chains

of the amino acid histidine. This resistance has developed as a result of the targeted high dose and extended release of the antibiotic by the bacteria. Many infectious disorders can be effectively treated with nanotechnology.

Due to their small size and porous structure, nano sponges can bind poorly soluble medicines inside their matrix and increase their bioavailability, making them crucial tools in drug administration. They can be engineered to deliver medications to particular locations, assisting in the reduction of drug and protein degradation and extending the effects of medications in a controlled way.

10. NANOTECHNOLOGY AND CANCER TREATMENT

Unbelievably many people throughout the world struggle with cancer, underscoring the need for an accurate diagnostic approach and an unique medicine delivery system that is more focused, effective, and has few side effects. If the therapeutic drug can reach the precise target spot without producing any adverse effects, anticancer treatments are frequently considered to be superior. This necessary focused delivery may be made better by chemically altering the surface of nanoparticle carriers. The addition of PEG or polyethylene oxide to nanoparticle surfaces is among the best illustrations of surface alterations. These changes improve the ability to target tumours as well as the specificity of drug uptake. PEG incorporation prevents the immune system from identifying nanoparticles as foreign substances, allowing them to travel through the circulation and eventually reach the tumour. Hydrogel's use in the treatment of breast cancer is another excellent example of this cutting- edge technology. Herceptin is a type of monoclonal antibody used to treat breast cancer by specifically targeting cancer cells' HER2 receptor. Thus, a hydrogel based on vitamin E has been created that can deliver Herceptin to the target spot for a number of weeks with just one dose. The hydrogel-based drug delivery is more effective than traditional subcutaneous and intravenous delivery routes because to the enhanced retention of Herceptin within the tumour, making it a more effective anti-tumor agent. Through the application of nanotechnologies, nanoparticles can be altered in a number of ways to extend circulation, improve drug localization, boost medication efficacy, and possibly slow the emergence of multidrug resistance.

11. CONCLUSION

Nano materials are a viable tool for the development of drug and gene delivery, biomedical imaging, and diagnostic biosensors due to their enhanced surface area and nano size effects. Comparing nanomaterials to their larger counterparts reveals that they possess special physicochemical and biological characteristics. Due to their unusual size, shape, chemical composition, surface structure, charge, solubility, and agglomeration, the characteristics of nanomaterials can significantly affect how they interact with biological molecules and cells. For example, nano particles can be used to produce exceptional images of tumor sites; single-walled carbon nanotubes, have been used as high-efficiency delivery transporters for biomolecules into cells.

Without a question, nanotechnologies have contributed to improvements in patient quality of life by fostering innovation in the biotechnological, pharmaceutical, and medical fields. Additionally, they have made it easier to domedical treatments, including diagnosis, therapeutic interventions, and follow- up monitoring. With the ultimate goal of making medical procedures more individualised, affordable, and safe, there is a continuing push to invent and develop innovative nanomaterials to enhance diagnostics and therapies for diseases in a targeted, accurate, potent, and long-lasting manner. The potentialof nanotechnology lies in selecting the best nanomaterials and minimising any negative impacts that can arise. To reduce any potential risks to human health and the environment, risk assessments are necessary before new nano-based products are licenced for clinical and commercial usage, just like with any otherproduct. To more precisely determine the long-term sustainability and safety oftheir use, a thorough life cycle analysis is necessary.

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