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A DETAILED REVIEW OF NANOTECHNOLOGY IN THE PHARMA INDUSTRY

BY

Jatin V. Thake[1], Nikita Kannor[2]
[1,2]S.M.B.T College of Pharmacy, Department of Pharmaceutical Chemistry, Nashik, INDIA

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Abstract

Nanotechnology is a multidisciplinary scientific subject concerned with the design, fabrication, characterization, and use of structures, devices, and systems on the nanometric scale. By manipulating shape and size at the nanoscale scale, nanotechnology is concerned with the design, characterization, production, and applications of structures, devices, and systems. By regulating better patient compliance, nanotechnology is related to the design, characterization, manufacture, and applications of structures, devices, and systems. Pharmaceutical nanotechnology includes the use of nanomaterials in pharmacy, as well as imaging, biosensor, and drug delivery systems. Pharmaceutical nanoparticles are sub nanoscale structures made of several tens or hundreds of atoms or molecules with a range of sizes (from 5 nm to 300 nm) and morphologies. They include drugs or bioactive chemicals.Nanotechnology's current position in the pharmaceutical industry includes the development of Nanomedicine, tissue engineering, nanorobots, biosensors, biomarkers, and so on. Pharmaceutical nanotechnology offers chances to improve materials, medical devices, and aid in the development of new technology in areas where existing and more traditional technologies may have reached their limits. Consequently, developments in this discipline will lead to enhanced drug delivery as well as other medical and pharmaceutical prospects in the approaching years. Nanotechnology, which uses nanostructures as a tool, has made improvements in disease diagnosis and treatment.These particles are made up of pure active pharmaceutical ingredient (API) and are frequently stabilized with surfactants and/or polymeric stabilizers affixed to their surface. The average particle size typically ranges from 1 nm to 1000 nm. This technology has shown promise in the treatment of cancer, AIDS, and a variety of other disorders. This review article focuses on recent breakthroughs in nanostructures and nanotechnology for medication delivery, nanomedicine, cures, drug discovery, cosmetics, the scope and opportunity of nanotechnology in pharmacy, the obstacles and prospects of nanotechnology in pharmacy, and the future of nanotechnology in pharmacy.

Keywords: *nanoparticles, nanoformulations, drug delivery, cancer, cosmetics*

Background

The prefix 'nano' is referred to a Greek prefix meaning 'dwarf' or something very small and depicts one thousand millionth of a meter (10−9 m). We should distinguish between nanoscience, and nanotechnology. Nanoscience is the study of structures and molecules on the scales of nanometers ranging between 1 and 100 nm, and the technology that utilizes it in practical applications such as devices etc. is called nanotechnology (Bayda et al., 2020)

Studies on nanotechnology and nanoscience have exploded during the past several years in a variety of product categories. It offers chances for the creation of materials, especially those for medical uses, while more traditional methods might have their limitations. Applications of nanotechnology in pharmacy that offer intelligent and smart medication delivery systems are anticipated to become the most significant and effective instrument as a replacement for conventional dosage forms. Pharmaceutical nanotechnology is a highly specialized and inventive discipline that will soon alter the pharmaceutical industry. Pharmaceutical nanotechnology offers ground-breaking chances to combat various ailments. It aids in the detection of the antigen linked to diseases including cancer, diabetes mellitus, and neurological illnesses as well as the detection of viruses and microbes(*Fullerene Nanogears*, n.d.). From the 1990s to the present, nanotechnology has brought about significant advances in several practical areas of health care. In the field of diagnostics, for example, nano-chips are utilized to produce self-testing and home diagnosis for certain disorders.

*Corresponding Author: **Jatin V. Thake**

Additional uses include employing quantum dots for more sensitive detection and nano needles to perform surgery on nanoscale structures inside living cells and tissues without inflicting any damage (Timmermans et al., 2011).

Pharmaceutical industries are concentrating their research on nanotechnology in light of the post-GATT (General Agreement of Trade and Tariffs) scenario because developing new chemical entities (NCEs) is a very time-consuming and expensive affair and most drugs will soon go off patent, causing huge revenue loss. Nanotechnology applications in pharmacy that offer intelligent and smart 32medication delivery systems are anticipated to become the most significant and effective instrument as an alternative to conventional dosage forms(N. K. Jain, 2007). Examples of such applications include innovative drug delivery systems employing nanoparticles(Hanes et al., 1997; LaVan et al., 2002; Lockman et al., 2002) or highly porous self-assembling bilayer tubule systems(Schnur, 1993; Schnur et al., 1994)(in certain cases specifically for the blood brain barrier). Chemically functionalized dendrimers, highly branched molecules with a "tree-like" branching structure that can be employed as molecular building blocks for gene therapy agents or as magnetic resonance imaging (MRI) contrast agents (Silva, 2004), are another class of applications being developed.

Nanotechnology is a multidisciplinary field that involves the fusion of many disciplines like molecular biology, biophysics, biochemistry, and bioengineering. The use of nano (bio) technology in molecular diagnostics, advancements in drug discovery, design, and delivery, including nano pharmaceuticals, is known as nanomedicine. Its effects can be seen in a number of medical specialties, such as tissue engineering, cancer, cardiology, immunology, brain targeting, gene delivery, etc. Oncology medication targeting is one of the most researched areas (Leucuta, 2010)

Main Text

1. Nanoparticles–essential component of nanotechnology

Nanotechnology is concerned with the creation and application of structures and devices with organizational features at the intermediate size between individual molecules and around 100 nm, where unique qualities emerge in comparison to bulk materials. It denotes the ability to construct customized nanostructures and devices for specific tasks through atomic and molecular control(Roco, 1999)According to the IUPAC, a nanoparticle is any particle having dimensions between 1 and 100 nm. However, there is no particular justification for using 100 nm as the size that distinguishes nanoparticles from non-nanoparticles. If the size is below 100 nm, the only guiding principle for differentiating nanoparticles is that unique properties, which bulk materials normally do not have, can be generated. The IUPAC definition of a nanoparticle also includes things with only two dimensions that are smaller than 100 nm, such as tubes and threads.So, the definition of a nanoparticle is more dependent on whether the particles exhibit novel characteristics that non-nanoparticles made of the same material do not(Lee et al., 2015)

For nanoparticles, various methods of preparation have been identified, including solvent evaporation, HPR, nanoprecipitation, salting out, microemulsion ball milling, and detergent removal. Since the area expands at a rapid pace, a wide range of preparation methods for nano-material formulation have been created. Yet, there are some important features of nanoparticles and drug encapsulation to consider. The material used for formulation is chosen based on various parameters, including, but not limited to, the nanometric size of particles necessary, surface qualities required, properties of the medication to be encapsulated, and bioavailability and toxicity limitations required (Cooper et al., 2014)

The primary goals of developing nanoparticles as a delivery system are to manage particle size, surface characteristics, and the release of pharmacologically active ingredients in order to produce site-specific action of the medication at the appropriate pace and dose(Vila et al., 2002). Polymeric nanoparticles have a few benefits over liposomes. These, for example, aid in drug/protein stability and provide valuable controlled release features.(Mu & Feng, 2003)

Using nanoparticles as therapeutic and diagnostic tools, as well as to improve medication delivery, is crucial and urgent for a number of reasons. One of them is the fact that conventional medications, which are currently accessible for oral or injectable delivery, are not necessarily produced using the best formulation for each product. For products containing proteins or nucleic acids to increase their effectiveness and safeguard them from unintended degradation, a more novel sort of carrier system is needed.It is worth noting that the effectiveness of most medication delivery methods is directly proportional to particle size (excluding intravenous and solution). Because of their tiny size and wide surface area, drug nanoparticles have increased solubility and hence greater bioavailability, as well as the capacity to penetrate the blood brain barrier (BBB), enter the pulmonary system, and be absorbed through the skin's tight connections of endothelial cells (Rizvi & Saleh, 2018)

Nanoparticles are viewed as either building blocks for materials and devices with specialized properties or as agents of change in a variety of events and processes. Nanoparticles have important uses in biological systems, the environment, consolidated materials, functional nanostructures, dispersions and coatings, and functional nanostructures. Research on nanoparticles and nanotechnology shows that different strengths have emerged in different nations(Roco, 1999).Since they are so small, nanoparticles can transport medications to practically any portion of the human body. Medicines can be chemically attached to the nanoparticles through encapsulation or a wide variety of linker molecules. This makes toxicokinetic easier to manage. The capacity to deliver drugs just where they are needed is the key benefit, though(Omlor et al., 2015).Smart nanoparticles can be developed to deliver therapeutic medicines to specific intracellular organelles(Liu et al., 2020). This enhanced

*Corresponding Author: Jatin V. Thake

technique would enable more efficient drug accumulation in the targeted spot (Nag & Delehanty, 2019), precision medicine, and the potential to overcome drug resistance (Deng et al., 2021). For example, a mitochondrial drug targeting technique has shown encouraging results in overcoming multidrug resistance in malignancies, particularly lung cancer, by inhibiting the upregulation of ATP-driven drug efflux pumps (H. Wang et al., 2018) .

With the rapid development of biocompatible nanotechnologies, the potential for molecular imaging and therapy will now be expanded with a variety of innovative agents. Long circulating half-times, selective binding to target cells or molecules, pronounced contrast to noise enhancement, low toxicity profile, ease of production, detection using common, commercially available imaging modalities, and potential for adjunctive therapeutic delivery are the ideal properties of such agents. By concentrating on cellular and molecular illness causes, these agents are anticipated to revolutionize imaging practice in the clinical setting. This will open up possibilities for the precise and logical design of drug- and/or gene-delivery nano systems(Patel & Bailey, 2007)

These microscopic particles can enter the body through the skin, lungs, or digestive system, deposit in several organs, and may induce significant unfavorable biological reactions by changing the physiochemical characteristics of tissue. Whenutilized for medication delivery, non-biodegradable particles may accumulate at the drug delivery site, triggering long-lasting inflammatory responses. Inhalation of particulate matter that causes lung and cardiovascular illnesses is the primary cause of the majority of nanoparticulate toxicity reactions(Konwar & Ahmed, 2016)

2. Pharmaceutical Applications of Nanotechnology

2.1. Nanotechnology in Drug delivery

For the foreseeable future, the application of nanotechnology to medication delivery is widely expected to revolutionize the landscape of the pharmaceutical and biotechnology sectors. Many pharmaceutical companies' pipelines are expected to be drying up, and a number of blockbuster treatments will go off patent in the near future. Too far, approximately two dozen nanotechnology therapeutic items have been approved for clinical usage.Liposomal medicines and polymer drug conjugates are two of the most common first-generation products(Glass, 2004; Langer, 1990; Wagner et al., 2006; Whitesides, 2003).

Novel drug delivery methods are essential strategic instruments, but their simplicity of administration is still lacking. The pharmaceutical business uses several potential therapeutics to boost drug markets. Nanotechnology can be successfully employed in both basic biology and the creation of novel biological technologies such as biocompatible medication delivery systems, imaging probes, and nanodevices(Azad & Rojanasakul, 2006). There are several uses for nanotechnology, and one of them is the development of medication delivery systems for the treatment and prevention of various diseases. The creation of medication delivery systems based on nanoparticles has increased our ability to diagnose and treat difficult diseases. Drug delivery to specific areas of the human body is now possible with the help of nanoparticle modifications. These tiny entities can also be used to track drug accumulation and metabolism in cells or tissues to learn more about the pharmacokinetics and pharmacodynamics of a certain medicine(Chan & Nie, 1998; de Jong, 2008; A. U. Khan et al., 2019; M. M. Khan et al., 2012; M. M. Khan & Cho, 2018) .

Nanotechnology applications in medicine are particularly promising, with fields such as illness detection, drug administration targeted at specific places in the body, and molecular imaging being extensively researched and some items entering clinical trials(K. C. P. Li et al., 2004; Moghimi et al., 2005; Shaffer, 2005; Wilkinson, 2003a). Although the full reach of these technical improvements in the field of human health care remains unknown, recent advances imply that nanotechnology will have a dramatic impact on illness prevention, diagnosis, and treatment (CHENG et al., 2006; Emerich, 2005; K. Jain, 2003; Sahoo & Labhasetwar, 2003; Wilkinson, 2003b).Much research has been conducted in recent years to create nanotechnology for drug delivery because it is an appropriate technique for delivering biotechnology-based medications such as proteins, peptides, or genes to the target tissue via either local or site-specific delivery (Azad & Rojanasakul, 2006). The optimal nanoparticle drug delivery system should be capable of locating, identifying, binding to, and delivering its load to specific diseased tissues while minimizing or preventing drug-induced harm to healthy tissues. Thus, the most popular tactic is to encapsulate particular targeted ligand(s) on the surface of nanoparticles. These targeting ligands may take the form of nucleic acid aptamers, antibodies, small molecules, peptides, proteins, or specialized proteins (Rizvi & Saleh, 2018)

For currently accessible bioactive, nanotechnology-enabled drug delivery systems with optimized physical, chemical, and biological properties can be used as efficient delivery mechanisms. Polymeric nanoparticles, liposomes, dendrimers, polymeric micelles, polymer-drug conjugates, and antibody-drug conjugates are some examples of nano-based drug delivery tools. These can be broadly categorized as I sustained and controlled delivery systems, (ii) stimuli sensitive delivery systems, (iii) functional systems for delivery of bioactive, (iii) multifunctional systems for combined delivery of therapeutics, biosensing, and diagnostic, and (N. K. Jain, 2007).

Indeed, a number of physiological factors can modify the physiology of sick tissues, which can be used to passively target medications. Consequently, it achieves site-specific and targeted medication administration by taking advantage of the structural variations between healthy and sick tissues. Hence, nanotechnology-based products have an advantage over conventional medicines(Sahoo et al., 2007)

The use of big sized materials in drug administration presents significant obstacles, such as in vivo instability, low

*Corresponding Author: Jatin V. Thake

bioavailability and solubility, poor absorption in the body, issues with target-specific delivery and tonic efficacy, and potential adverse pharmacological effects. As a result, adopting innovative drug delivery systems to target medications to specific body areas may be an alternative for resolving these essential difficulties. As a result, nanotechnology is playing an important part in enhanced medicine/drug formulations, targeting arena, and controlled medication release and delivery with great success(Jahangirian et al., 2017; Martinho et al., 2011).

The use of nanoparticles as drug carriers has the potential to minimize the toxicity of the drug contained. In general, the toxicity of the entire formulation is studied, but the results of the nanoparticles themselves are not disclosed. As a result, distinguishing between medication and nanoparticle toxicity is impossible. As a result, the toxicity of "empty" non-drug laden particles should be highlighted. This is especially relevant when slowly or non-degradable particles are used for drug administration which may display persistence and aggregation on the site of the drug delivery, eventually leading in chronic inflammatory reactions(De Jong & Borm, 2008)

2.2. Nanotechnologyin cancertreatment

Fermentation and cell death have the potential to upset the natural equilibrium that maintains tissue homeostasis. Gene mutations occur as a result of the body's exposure to mutagenic agents. Cancer development is a multistage disease process in which normal cells become malignant through a gradual progressive series of fundamental cellular abnormalities that result in uncontrolled and continuous proliferation of cancer cells. The primary characteristic of cancer development is the accumulation of mutations; DNA damage and alterations to cell cycle regulation play a crucial part (Leucuta, 2010)

The therapies currently utilized to treat cancer patients have saved lives, but because chemotherapeutic drugs are non-specific, there are severe side effects that affect the entire body. A biological process as complex as cancer might be thought of as an illness of many diseases. The ability of malignant cells to rapidly divide and grow uncontrollably is one of their distinguishing features(A. U. Khan et al., 2020)

Nanotechnology has the potential to revolutionize cancer detection and treatment. Surgery, chemotherapy, immunotherapy, and radiation are some of the most often used cancer treatments. einsteineruploading up to get together with(N. K. Jain, 2007).Nano shells, nanocantilevers, nanoprobes, nanocrystals, nano polymers, quantum dots, and dendrimers are just a few of the nanotechnologies that can be used to treat cancer (LaRocque et al., 2009; Patra et al., 2018b) .Two crucial aspects of the development of nanomaterials for cancer therapy are the ability to detect tumors and reach the target tumor site without harming healthy cells. Numerous nanoparticles show promise in their capacity to recognize highly sensitive and specific cancer cells via various mechanisms. These nanoparticles stand out from other cancer treatments thanks to their special qualities (Misra et al., 2010).In cancer detection and therapy, nanotechnology has revolutionized. It is capable of identifying even one malignant cell in vivo and delivering extremely harmful medications to the diseased cells(Jaishree & Gupta, 2012). Because of the nano size of the carrier, nanocarriers can drastically affect the biodistribution and pharmacokinetic properties of an anticancer agent when compared to free drug. These nanotools identify biomarkers or detect mutations in cancer cells and treat the abnormal cells through I thermotherapy using silica nano shells and carbon nanotubes; magnetic field-induced thermotherapy using magnetic nanoparticles; photodynamic therapy using quantum dots as photosensitizers and carriers, (ii) chemotherapy using nano-structured polymer nanoparticles, dendrimers, and nano shells, and (iii) radiotherapy using carbon nanotubes, dendrimers(ii) Implantable delivery mechanisms(N. K. Jain, 2007)

The National Cancer Institute of the National Institutes of Health will invest $144.3 million in research and development over the next five years through the National Cancer Institute Alliance for Nanotechnology in Cancer. The Cancer Nanotechnology Plan will be implemented by the Alliance, and it will include six targeted programming areas: molecular imaging and early detection, in vivo imaging, efficacy reporters, multifunctional therapies, prevention and control, and research enablers. In conclusion, this research addressed a critical topic concerning the development of MEMS/NEMS (micro-electro-mechanical/nano-electro-mechanical systems) devices in cancer therapy(Yih & Wei, 2005)

2.3 Nanotechnology in drug development

The therapeutic benefits of nanotechnology-derived drug delivery are becoming clear and will soon be connected with all routes of drug administration. Lower medication toxicities, higher bioavailability, cheaper treatment economic costs, and increased patient adherence are all advantages over present treatment approaches. Nanotechnology has already had a significant influence on the medical care of cancer, but other medical specializations will soon use these innovative ways of drug delivery to achieve maximum therapeutic success (Kingsley et al., 2006)

Pharmaceutical nanotechnology is playing a critical role in the drug development process, which depends on a better knowledge of the medicine's mechanism of action and the finding of biomarkers linked to certain diseases. By locating the protein on the cell surface or target surface, nanotechnology aids in target identification and validation. Nanotechnology will improve the drug development process by automating, accelerating, and improving assays' reliability(M & Shailender, 2012). The biophysical and biological characteristics and nature of the targeted medications are the primary determinants of how nanotechnology will be applied in the drug development process. Pharmacokinetic and pharmaceutical companies have been attempting to reduce the price of drug development in recent years. The pressure on the pharmaceutical manufacturing industry is coming from the rivalry among generic manufacturers, rising production costs, and elevated

*Corresponding Author: Jatin V. Thake

failure rates. Drug development may be more economically feasible with the use of nanotechnology in both lifestyle management and drug development (Sahu et al., 2021b)

There has been a lot of attention lately in creating new medicine delivery systems that use nanotechnology. A regulated and targeted drug release mechanism using nanoparticles appears promising. Dimensionality of the Particles, Surface-to-Volume Ratio, Surface Area, and Surface Free Energy Since they are only partially soluble in water, around 40% of the medicines created today are poor candidates for drug delivery formulations. A medicine is more effectively dissolved and soluble when it is nanosized or prepared as a nanoparticulate system (Ravichandran, 2009). Solid NPs with and without surface functionality have been created using a variety of materials up to this point. Aliphatic polyesters like poly (lactic acid), hydrophilic poly (glycolic acid), and their copolymers, such as poly (lactic acid), may be the most commonly utilized (lactide-coglycolide). It is essential for NPs in the dose to retain their particle size during the course of their self-life in order for development to be effective, which can aid in enhancing the stability of medications (Sahu et al., 2021a).

Nanomedicine is a branch of medicine that uses nanotechnology to prevent and cure diseases by using nanoscale materials such as biocompatible nanoparticles and nanorobots for a variety of applications such as diagnosis, delivery, sensory, or actuation purposes in a living organism (Patra et al., 2018a). Nanomedicine has sparked numerous debates and concerns among scientists, philosophers, ethicists, and policymakers. Nano pharmacy is a subfield of nanomedicine that is already finding its way from the lab to the marketplace. As an example of merging technologies, nano pharmacy raises a slew of ethical and social challenges arising from many technologies such as nanotechnology, bioelectronics, and ICT in general. Nano pharmaceutical developments, in addition to raising significant ethical concerns, have far-reaching ramifications for health care in general (Timmermans et al., 2011).For medication and gene delivery applications, nano systems with various compositions and biological properties have been intensively researched (Suri et al., 2007).Nanomedicine's goal is to enhance healthcare for the benefit of patients. The use of nanotechnology in healthcare has given rise to the significant and quickly expanding discipline of nanomedicine(A. U. Khan et al., 2020).Many anticancer medications have been effectively manufactured utilizing nanomaterials, including paclitaxel, doxorubicin, 5-fluorouracil, and dexamethasone. For in vitro RNAi delivery, quantum dots, chitosan, polylactic/ glycolic acid (PLGA), and PLGA-based nanoparticles have all been employed (Ferrari, 2005).

Drug development relies on a better knowledge of the drug's mechanism of action and the finding of biomarkers linked to certain diseases, and pharmaceutical nanotechnology is playing a critical role in this process. By locating the protein on the target surface or cell surface, nanotechnology aids in target identification and validation. By automating, accelerating, and improving tests, nanotechnology will improve the drug development process(N. K. Jain, 2007)

2.4 Nanotechnology in cosmetics

The traditional cosmetics form has evolved over time by adjusting to changes and is currently accepted based on scientific and technical study. The acceptance of cosmetic items was confirmed by in vivo and in vitro research, and the cosmetics sector offers fresh alternatives to this inclination with a variety of cutting-edge skin products (Khezri et al., 2018).

Cosmetics with physiologically active ingredients that have therapeutic effects on the surface applied are known as cosmeceuticals. As they promise to improve appearance, they are used as cosmetics. Between medications and personal care items, there is a gulf called cosmetics. Cosmeceutical products have verifiable therapeutic efficacy on the skin since they are used to treat a variety of disorders, including hair loss, wrinkles, photoaging, skin dryness, dark spots, uneven skin tone, hyperpigmentation, and others (Kaul et al., 2018).

Nano-sized components can be found in a variety of modern cosmetic products, including moisturisers, hair care products, and make-up. Liposome-based anti-aging topical formulations (creams, lotions, gels, and hydrogels, for example) have been formulated into the cosmetic market by L'Oréal in the form of niosomes and by Christian Dior in the form of liposomes (CaptureTM) since 1986(Mu & Sprando, 2010)

Many cosmetic products contain nanoparticles. Nanometre-scale materials in these products provide greater clarity, coverage, cleansing, or absorption. For instance, the nanoparticles used in sunscreen (titanium dioxide and zincoxide) provide reliable, extensive protection from harmful UV radiation.

Thesenanomaterials offer better light reflection for a longer time period(*Learn with Us*, n.d.). With their role in the various offered formulations in mind, the uses of nano systems in cosmetics are outlined. These nanostructures may be found in many different cosmetic goods, aiding in the penetration of ACIs that fight ageing or skin whitening, extending the wear time of makeup, acting as carriers for ACIs that fight germs in deodorants, and even being present in UV protection products(Santos et al., 2019).Many nanoparticles used in cosmetic goods that advertise improved skin absorption may actually be unstable when applied to the skin and incapable of delivering substances below the skin's surface layer. Yet, they might make the skin more receptive to cosmetics by encouraging greater diffusion from the cosmetic vehicle into the epidermal layer. Only insoluble, stable nanoparticles, such as polymers, nanogold, nano silver, and titanium dioxide, are categorically classified as potentially entering the body and directly posing a risk to health(Katz et al., 2015)

2.5 Nanotechnology in cardiovascular diseases

Cardiovascular illnesses have remained a prominent source of death and morbidity around the world. Adult cardiomyocytes' inability to proliferate prevents the heart from rebuilding new myocardium following a myocardial ischemia event,

*Corresponding Author: Jatin V. Thake

weakening the heart over time and potentially leading to heart failure and death. Early introduction of cardioprotective medicines can help protect the heart from additional cell death and enhance cardiac function, but delivery methods and associated side effects of these therapies may be an issue Developments in nanotechnology, particularly nanoparticles for drug administration, have enabled researchers to improve drug targeting capability, hence improving therapeutic outcomes(La Francesca, 2011) Cardiovascular disorders (CVDs), which include acute myocardial infarction (AMI), hypertension, atherosclerosis, stroke, and heart failure, are among the most dangerous and deadly diseases, causing enormous health and economic costs worldwide(T. Li et al., 2018)

Nanotechnology will become more and more important in cardiovascular treatment in the near future. Nanoscale (i.e., less than 100 nm) structures, devices, and systems with innovative features and functionalities connected to the size and structure are used in nanotechnology, which is a byproduct of research and development. Many prospects exist for the treatment of cardiovascular disease as a result of recent, rapid breakthroughs in nanotechnology and nanoscience. Focusing on materials at the atomic, molecular, and super molecular levels, nanotechnology and nanoscience develop innovative molecular assemblies and plan systems of self-assembly for individual cells (Wei et al., 2007)

According to the National Nanotechnology Initiative's definition, nanotechnology makes use of particular phenomena and the direct manipulation of materials at the nanoscale. But nanotechnology is much more than just the study of tiny objects; it is the investigation and creation of substances, tools, and systems with unique physical, chemical, and biological qualities. Since each of these technologies may have distinct properties and uses, nanotechnology is best understood as a broad collection of technologies from a variety of disciplines, including physics, materials science, engineering, chemistry, biochemistry, medicine, and optics(Kong et al., 2006). Tools based on nanotechnology can be used successfully to treat cardiovascular disorders. These instruments can be applied to tissue engineering, imaging, and diagnostics. Quantum dots (QDs), nanocrystals, and nano barcodes are examples of miniature nanoscale sensors that can detect and track biological signals such the release of proteins or antibodies in response to cardiac or inflammatory events (Sahoo et al., 2007).

Deepening understanding and expanding usage of nanotechnology as a therapeutic tool for the treatment of numerous cardiovascular illnesses will enable clinicians to achieve hitherto impossible goals. This prospect transforms nanomedicine, along with its advances and applications, into a true light at the end of the tunnel, providing great hope for the recovery of patients suffering from diseases such as hypertension and atherosclerosis, or who have suffered a cardiovascular event with disabling sequelae such as AMI or stroke, in the near future. At the same time, it is likely that even these significant advances are merely the beginning of a massive growth and development in the field of public health around the world (Martín Giménez et al., 2017)

3. Scope and opportunity of nanotechnology in pharmacy

Pharmaceutical nanotechnology is a cutting-edge, highly specialized discipline that will transform the pharmaceutical industry in the near future. Pharmaceutical nanotechnology offers game-changing opportunities to combat a wide range of ailments. It aids in the detection of antigens linked to diseases such as cancer, diabetes, and neurological diseases, as well as the detection of bacteria and viruses(M & Shailender, 2012). The application of nanotechnology to medicine, specifically drug delivery, is expected to grow quickly. Pharmaceutical sciences have used nanoparticles to lessen the toxicity and adverse effects of medications for many years(De Jong & Borm, 2008).Drug formulation, disease diagnostics, improving access to clean water, and increasing energy output have all benefited from the use of nanotechnologies. Several medicine formulations based on nanotechnology have been released into the market to treat a variety of illnesses, including as cancerdiseases of the central nervous system (CNS), cardiovascular disease, and infection control. Drug delivery using tiny particles or molecules to enhance the bioavailability and pharmacokinetics of therapies, such as liposomes, polymer nanoparticles, nano-suspensions, and polymer therapeutics, is another application of nanotechnology (Al-Nemrawi et al., 2020)

Pharmaceutical industries are concentrating their research on nanotechnology in light of the post-GATT scenario because developing NCEs is a very time-consuming and expensive affair and most drugs will soon go off patent, causing huge revenue loss. Nanotechnology applications in pharmacy that offer intelligent and smart medication delivery systems are anticipated to become the most significant and effective instrument as an alternative to conventional dosage forms. Due to new patent protection for current or soon-to-be off-patent medications, these nano-intelligent drug delivery systems need little investment but are anticipated to be a highly profitable deal(N. K. Jain, 2007)

There are, however, barriers to broad usage of nanotechnology in pharmacological and medical applications. Notwithstanding the remarkable success and safety records of rDNA insulin, human growth hormone, and hepatitis B vaccine, public sentiment is growing against genetically modified food products. Every effort should be taken to reduce societal hazards, and the public should be educated to understand the beneficial benefits of these new technology. The application of nanotechnology to pharmaceutical research is likely to result in a wide range of commercialization options (Hobson, 2009)

*Corresponding Author: **Jatin V. Thake**

4. Challenges to pharmaceutical nanotechnology

Pharmaceutical nanotechnology has enabled more accurate illness detection and targeted treatment. In spite of this, there are a number of ethical, scientific, social, and regulatory issues that provide difficulties for the practical application of pharmaceutical nanotechnology. Cytotoxicity, translocation to undesirable cells, acute and chronic toxicity, some unidentified, unanticipated, and undefined safety difficulties, environmental effects of nanomaterials, and non-biocompatibility are some of the significant health risks connected with such devices (M & Shailender, 2012).

Hype, over-used vocabulary, and unrealistic expectations Aside from the capabilities of nanomedicine, the practical realities of moving in vivo nanotechnology applications towards clinical use face a number of technical and scientific hurdles. Regardless matter how exciting the science is, converting in vitro innovations to applications must provide obvious performance advantages for adopting certain nano-component or micro designs (Y. Wang & Grainger, 2014).

Because to the high expenses of medical aid and treatment, the possibility for self-diagnosis that is connected to nanomedicine may cause people to avoid going to doctors. Although it has been stated that nanomedicine will be costly due to the high development expenses involved, it is expected that, similar to other high-tech items like laptops, the price will fall significantly once they are mass-produced. In fact, one of the primary justifications given by pharmaceutical corporations for investing in nanotechnology is the potential long-term cost savings (Timmermans et al., 2011).

5. Future of nanotechnology in pharmacy field

Emerging pharmaceutical nanotechnology has the potential to have a significant effect on people's health. Nanomaterials are being employed more frequently in tissue engineering and drug delivery applications, both of which have the potential to change medicine (M & Shailender, 2012). Although nanotechnology has a bright future, it's crucial to take into account how hazardous nanoparticles might be. To ensure that these materials won't affect biological processes within the human body, toxicity screening of nanotechnology products should involve physiochemical characterization of the nanomaterial, in vitro experiments, and in vivo research(Kingsley et al., 2006). Nanotechnology has been shown to be effective in the treatment of cancer and many other diseases, as well as in diagnostic testing and treatments. Nanotechnology can also bring up new possibilities in implanted delivery devices, which are generally preferred to injectable medications because the latter frequently exhibit first order kinetics (the blood concentration rises rapidly but falls exponentially over time)(A. U. Khan et al., 2020).

Regardless of how nanoparticle drug delivery systems are engineered in the future, drug delivery experts must be cognizant that nanoparticles will need to rely on blood circulation to reach target areas for efficacy. This reduces the percentage of the medicine that reaches the tumors. Because nanoparticle formulations only deliver a small proportion of the total administered dose to the target tumor, it is crucial to maximize the drug's potency at the target. This necessitates new approaches to creating nanoparticle compositions. Simultaneously, efforts must be made to reduce the medicine's negative effects by changing biodistribution and/or restricting drug release to non-target areas (Lee et al., 2015)

These multifunctional nanoplatforms would be able to locate to target cells, enable diagnostics, and then distribute treatments with pinpoint accuracy. Yet, such techniques to nanodevice development are intrinsically complex. One highly fascinating and new future technique is to create a nanomachine that can identify and kill pathogens at the same time, detect changes in molecular events during diseased states, and assess treatment efficacy (N. K. Jain, 2007)

Conclusion

Nanotechnology is genuinely an interdisciplinary discipline, with chemists, physicists, biologists, and pharmaceutical experts all playing important roles in the development of innovative medicines and diagnostic modalities. Nanotechnology has been shown to be effective in the treatment of cancer, cardiovascular disease and many other diseases, as well as in diagnostic testing and treatments. Nanotechnology has the potential to create new options in implanted delivery systems.This paper demonstrates how the use of nanotechnology in drug development, drug transport, nanomedicine, cosmetics, and cure can open up new avenues for giving more personalized, safer, and effective treatment alternatives. significant pharmaceutical nanotechnology provides new tools, chances, and scope that are likely to have an impact on many aspects of disease detection and therapy. Pharmaceutical nanotechnology gives pharmaceutical firms fresh hope by supplying cutting-edge patentable technologies in response to income loss caused by off-patent medications. Scientific societies, corporations, and governments all across the world are waiting with bated breath to seize the possibilities of this technology. This technique has the potential to significantly improve illness detection, diagnosis, treatment, and prevention.Nanotechnology is widely employed and has proven to be advantageous in dermatology, cosmetics, and medicinal applications.In short, current developments, market realization of various pharmacological nanotools, and global interest demonstrated by scientists, governments, and enterprises ensure that nano-based drug delivery systems have enormous potential and scope in the near future. There is little doubt that the market will be swamped with nano-enabled delivery devices and materials during the decade to come.

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*Corresponding Author: **Jatin V. Thake**