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Review Article

TYPES AND APPLICATION OF PHARMACEUTICAL NANOTECHNOLOGY: A REVIEW

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ABSTRACT

The already enormous health industry will continue to expand as baby boomers begin to enter retirement. Pharmaceutical companies will create new technologies in response to patient expectations, given the size of the customer base and the increasing demand. As pharmaceuticals get more complex and hazardous, new distribution strategies are needed to get them to the correct areas of the body. As a result, well-known pharmaceutical companies are utilising cutting-edge methodologies and technology. One of the most comprehensive technologies is pharmaceutical nanotechnology. Pharmaceutical nanotechnology offers new opportunities, tools, and breadth that are expected to have a big influence on a lot of areas of illness diagnosis and treatment. Pharmaceutical nanotechnology has opportunities to improve materials and medical technology as well as to contribute to the advancement of technology in fields where more seasoned and conventional technologies may be nearing their limits. In conclusion, recent developments, the commercialization of several pharmaceutical nano-tools, and the rising interest of academics, governments, and corporations ensure that nano-based drug delivery systems in the near future have immense potential and range.

Keywords: Nano-particles, Pharmaceutics nano-medicine, Cancer treatment, Future of nanotechnology

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INTRODUCTION

Nanotechnology is the study of producing and applying nanoparticles, which are small enough to be measured in nanometers. In other words, nanotechnology is the systematic characterization, manipulation, and organisation of matter at the nanoscale scale, which has changed science, engineering, technology, medicine delivery, and therapies. Typical accessible structures are frequently sub-micrometer in size, lying inside the optical resolution envelope, and are just faintly discernible with a microscopic study. Because a typical organizational size is now in the nanoscale range, recent advances have concentrated on the size range below these dimensions, and the procedures and methods are known as "nanotechnology" [1, 2]. Until they reach the area of the body where the disease is prevalent, drugs normally travel throughout the body. These nanotechnology-based drugs can target medicine to a particular location, boosting efficacy and reducing the likelihood of adverse effects. Target-specific drug treatment and early illness detection are top research priorities where nanotechnology may be essential [3].

The two main types of pharmaceutical nanotechnology-nanomaterials and nanodevices-which are significant in other industries as, well-are separated into these two groups. The biomaterials used in dental or orthopaedic implants as well as scaffolds for products made of tissue engineering, are where the nanoparticles come from. To increase their biocompatibility with human tissue, they can have their surface modified or coated. These are further separated into two categories: nanocrystalline and nanostructured components. Nanocrystals are ground in specialised mills to create drugs that may be breathed or given intravenously as nanosuspensions. The small size of practically insoluble medications improves the surface/volume ratio and bioavailability. Nanomaterials that have undergone processing to produce distinctive forms and features are known as nanostructured materials [4-6].

Nanomaterials are commonly used in pharmaceutical delivery because they can enhance solubilization, which results in controlled release and/or drug targeting. They are used in asthma inhalers, hormone administration through the skin, drug delivery through the eye, oral and vaccine delivery techniques, gene delivery, cancer therapy, and other applications. Nanoparticles are used by several companies to treat cancer. Nanodevices include things like microfluidics (which controls and manipulates fluids in the micro-or nanoliter range), nano- and micro-electromechanical systems (NEMS/MEMS), and microarrays (which performs numerous biological tests including DNA, protein, cell, and antibody analysis) [7, 8]. These comprise biological threats, symptoms of disease, airborne infections, biosensors and detectors that spot minute concentrations of microbes, and some advanced technology like respirocytes [9].

Types of pharmaceutical nano-particles

Liposomes

Liposomes, also known as lipid vesicles, were the first type of nanomaterial to be employed in the administration of medication and were originally discovered in 1976. In order to surround an aqueous core, liposomes, which are spherical vesicles comprised of cholesterol and amphiphilic phospholipids, self-assemble into bilayers. The amphiphilic phospholipid molecules form a tight bilayer sphere to shield their hydrophobic core from the aquatic environment while maintaining contact with it through the hydrophilic head group. A hydrophobic membrane can be found inside a liposome that contains an aqueous solution, inhibiting the passage of hydrophilic solutes through the lipids. Therefore, hydrophobic and hydrophilic molecules can be found in the outer membrane of lipsomes (the inner aqueous core). According to the size and number of their bilayers, the three different forms of liposomes that may be classed are multilamellar vesicles, big unilamellar vesicles, and tiny unilamellar vesicles. It has been exhaustively investigated if liposomes may be used to treat cancer. Drug-delivery systems are more effective because of their small size, decreased drug toxicity, time-controlled drug release, changed pharmacokinetics, and altered biological dispersion of the medicine [10-12].

Carbon-nanotubes

Carbon nanotubes are carbon cylinders formed of benzene rings that are used as diagnostic instruments for discriminating between proteins in serum samples, carriers to deliver medications, vaccinations, or proteins, and sensors for detecting DNA and proteins. Single-walled carbon nanotubes have been widely used as a platform for researching external and protein-protein interactions as well as developing extremely accurate electrical biomolecule detectors. Carbon nanotubes are made of hexagonal carbon networks. These tubes range in length from 1 to 100 nm and have a diameter of 1 nm [13]. The two kinds of nanotubes are single-wall nanotubes (SWNTS) and multi-wall nanotubes. (MWNTS) [14].

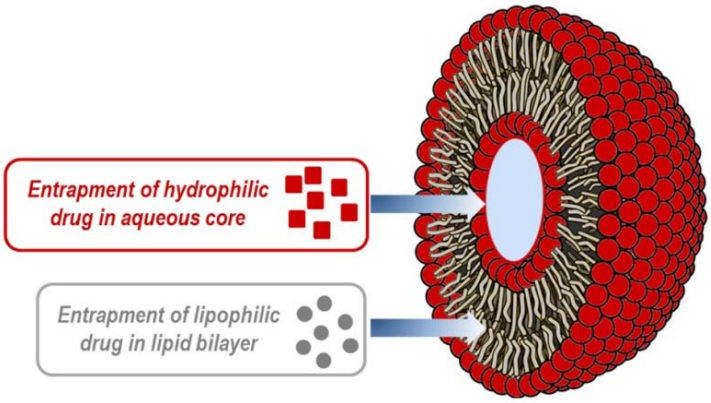

Fig. 1: Liposomes

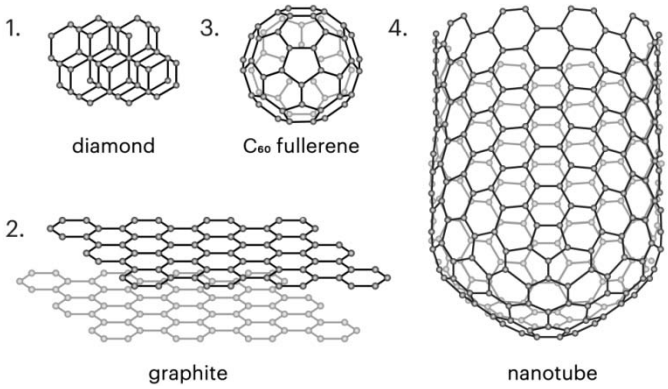

Fig. 2: Carbon nano-tubes

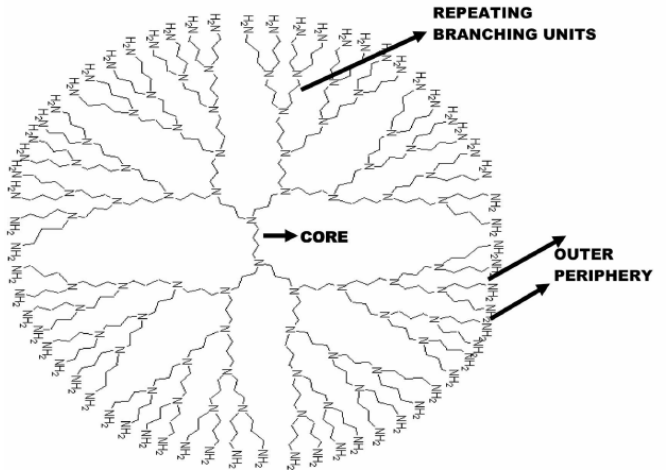

Fig. 3: Dendrimers

Polymeric nanoparticles

Polymeric nanoparticles are being developed as effective delivery methods in order to boost efficacy and lessen the side effects of chemotherapy drugs due to their passive tumor-targeting properties. Furthermore, the capacity of nanoparticles to preferentially accumulate in and around the tumour mass offers a platform for improved tumour identification, laying the foundation for the development of multifunctional nanoparticle systems for the treatment of cancer [15, 16]. These nanoparticles are an alternative to the nanosystems mentioned above because of their inherent properties, which include biocompatibility, non-immunogenicity, non-toxicity, and biodegradability. Additionally, natural macromolecules such as silica, metal oxides, non-polar lipids, proteins, and polysaccharides can be used to create nanospheres [17].

Dendrimers

Synthetic polymers called dendrimers have globular, branching structures with an initiating core and a number of layers with active terminal groups. A generation describes each of these layers, which are composed of repeating units. Generations zero refers to the centre of a dendrimer. Dendrimers have a special chemical structure that allows them to carry a wide range of drugs via covalent conjugation or electrostatic adsorption to their multivalent surfaces. Dendrimers, which are generally 10 to 100 nm in diameter and

employed in drug administration and imaging, make ideal transporters for targeted drug delivery due to the many functional groups on their surface. Dendrimers, however, have shown great promise in the delivery of anticancer medications when they have a polycationic surface that allows for multiple interactions with a variety of target receptors. However, the polycationic surface is also the main problem in medicinal delivery techniques due to its harmful effects on cell membranes [18, 19].

Quantum dots

QDs are used to track individual glycine receptors (GlyRs) and assess their dynamics in the neuronal membrane of live cells for times ranging from milliseconds to minutes. In recent years, several research teams have been interested in semiconductor quantum dots (QDs) because of their significance in microelectronics, optoelectronics, and cellular imaging. In order to improve its optical properties, the semiconducting material known as quantum dots comprises a semiconductor core that is encased in a shell. Their traits originate from the size of their bodies, which range in radius from 10-100A0 [20]. Quantum dots are widely employed in biomedical processes that need fluorescence, such as DNA array technology, cell biology, and immunofluorescence tests. This is especially true when it comes to proteins, cytoskeletal, actins, and nuclear antigens' immunoreactivity. The most popular QDs are cadmium selenide (CdSe), cadmium telluride (CdTe), indium phosphide (InP), and indium arsenide. (In As). Compared to conventional fluorescent dyes, these particles serve as contrast agents in bioimaging and provide far greater resolution. These nanoparticles have different bulk band gaps that correspond to different particle configurations and can absorb white light and fresh sources of value in nanoseconds [21-23].

Metallic nanoparticles

Silver and gold nanoparticles, though other metals have also been utilised to make nanoparticles, are especially important for biological purposes. Numerous ligands have been joined to nanoparticles, including sugar, peptides, proteins, and DNA. They have been used as an alternative to quantum dots for active delivery of bioactive, drug discovery, bioassays, detection, imaging, and a variety of other uses due to their propensity to have surfaces functionalized [24].

Polymeric micelles

A polymer micelle is a nanoparticle with a hydrophilic exterior and a hydrophobic inside. It may be divided into two main categories: micelles made of hydrophobic materials and polyion complexes. Amphiphilic copolymers from the past frequently contain both hydrophobic and hydrophilic building components. A balance between these two fundamental components leads to the spontaneous generation of nanoparticles in an aqueous phase. In the majority of block copolymers, poly (ethylene glycol, or PEG), is used as a hydrophilic block [25]. The hydrophobic properties of the polymers that make up the micelles' cores-which include biodegradable polyesters like poly (lactic acid), poly (e-caprolactone), and poly(glycolic acid)—lead to a variety of micelle characteristics (PGA).

Micelles are collections of the individual molecules that make up liquids. They feature a hydrophobic core that is shielded from water by a shell of hydrophilic groups. These are used to provide drugs systemically that are water-insoluble [26, 27].

Application of pharmaceutical nanotechnology

If poor adhesion and absorption are added throughout the entire rest of the body, a dose sufficient to be effective against the sick area of the body is likely to produce noticeably detrimental consequences. The medications now in use rely on a very minor variation in adhesion or absorption specificity. Pharmaceutical nanotechnology has also been centered on the following applications [28].

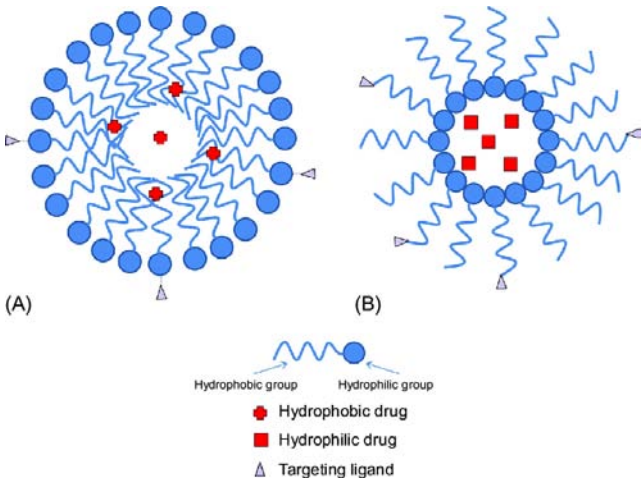

Fig. 4: Polymeric micelles

Engineering tissue

Nanotechnology has the potential to help in tissue regeneration or repair. Growth hormones and scaffolding made of the proper nanomaterials are used in "tissue engineering" to artificially boost cell proliferation. Tissue engineering has the potential to replace contemporary conventional treatments like organ transplants and implanted gadgets. Nano-and micro-technologies can be integrated with biomaterials to generate tissue-engineered scaffolding that can support and regulate cell behavior [29].

Chemical diagnostics

By merging nanoparticles with other nanotechnology-based materials, this new issue might be resolved and technologies developed that enable diagnostics at the level of individual molecules and cells. QD particles serve as contrast agents in bioimaging and provide a great deal more resolution than existing fluorescent dyes. Cadmium selenide (CdSe), cadmium telluride (CdTe), indium phosphide (InP), and indium arsenide are the most widely utilised QDs. (InAs) [30, 31].

Efficient delivery of drugs

Using nanoparticles to deliver medications has several advantages, including enhancing the therapeutic efficacy and pharmacological characteristics of the medicine. Although nanoparticles improve poorly water-soluble drug solubility, change pharmacokinetics, lengthen the half-life of drugs by lowering immunogenicity, increase drug precision for the target cell or tissue (thus reducing side effects), improve bioavailability, reduce drug metabolism, allow for a

more controlled release of therapeutic compounds, and facilitate the simultaneous delivery of two or more medications for combination treatment [32, 33].

In curing cancer

Colloidal drug delivery methods, including liposomes, micelles, and nanoparticles, have received substantial investigation for use in the treatment of cancer. Drug-delivery systems are more effective because of their small size, decreased drug toxicity, time-controlled drug release, changed pharmacokinetics, and altered biological dispersion of the medicine [34].

Implants and artificial organs

Another area where developments in nanotechnology might be efficiently applied is the creation of artificial cells, tissues, and organs. In-depth study is being done on artificial cells, particularly those that carry out metabolic functions, with the goal of replacing damaged or dysfunctional cells and organs.

Pharmaceutical drug discovery

Nanotechnology assists in the identification and validation of targets by identifying the protein on the interface or one was. Medicine distribution will be enhanced by nanotechnology through miniaturization, mechanization, imitation, and test reliability. Single-walled carbon nanotubes are good in identifying pathogen surface proteins. Quantum dots are used to monitor the movement of individual glycine receptors in the neuronal membrane of live cells for times ranging from milliseconds to hours. Gold nanoparticles and nano-bodies, which are the smallest, most accessible antigen-antibody fragments produced by ablynx, are two nanomaterial's that are often used in diagnostics [35, 36].

Aspects of pharmacological nanotechnology in the future

Pharmaceutical companies are struggling. As more "blockbuster" drug patents expire, top pharmaceutical corporations search for innovative, competitive business methods. A number of drugs might lose their patent protection by 2011, which could result in lost pharmaceutical revenues of $70-$80 billion. The vast majority of new medications are unable to get the market because of their subpar ADMET profiles. Recently, a number of nanotechnologies have been used successfully to treat medications with limited water solubility. Many pharmaceutical firms are reevaluating abandoned drugs that were "difficult" to make due to their solubility qualities by using nanotechnology [37].

Medical diagnostics, proper and efficient drug distribution, and the production of artificial cells are among the medical specialties where nano-size compounds have found practical uses. According to Freitas, nanomedicine, or the application of nanotechnology in medicine, includes three connected and gradually more effective molecular approaches. Similar gadgets loaded with certain "weapons" might be used to clear obstructions in the circulatory system or find and destroy cancer cells. Bacteria and viruses that have already largely acquired their motorization and genetic information transmission capabilities might also be modified to function as nano-robots [38-44].

CONCLUSION

Nowadays, nanotechnology is regarded as the underlying technology of the twenty-first century. These days, better composite materials, materials with increased catalytic activity, materials with increased hardness and abrasion resistance, and a variety of consumer goods (like cosmetics and sun protection) that enhance people's beings are all produced using nanostructured materials and nanotechnology techniques. Pharmaceutical nanotechnology offers enormous promise for producing intelligent tissue-engineered materials and delivering bioactives and diagnostics in both space and time. It offers new opportunities, tools, and a wider range of applications through its nano-engineered tools, which are projected to have a substantial influence on a variety of disease, diagnosis, prognosis, and disease treatment.

Pharmaceutical nanotechnology offers opportunities to improve materials, medical devices and support the development of new technologies in areas where more established and conventional technologies may be nearing their limits. It provides businesses fresh hope in light of the financial losses inflicted on by off-patent pharmaceuticals by providing new patented technologies. Modern nanotechnology will soon be available to us, greatly advancing illness detection, diagnosis, treatment, and preventative measures. Nanorobots and smart medicine are two examples.

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DATA AVAILABILITY

The original data that support the findings of this study are included in the Article.

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AUTHORS CONTRIBUTIONS

All the authors have contributed equally.

CONFLICTS OF INTERESTS

The authors confirm that the content of the article has no conflict of interest.

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