A REVIEW ON APPLICATIONS OF NANOTECHNOLOGY IN PHARMACEUTICAL INDUSTRY.

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Abstract: Pharmaceutical nanotechnology has become a ground-breaking method for drug delivery systems, providing improved effectiveness, less adverse effects, and precise targeting. This study examines the many uses of pharmaceutical nanotechnology in drug delivery, including different nano-sized carriers such micelles, liposomes, dendrimers, and polymeric nanoparticles. We examine the mechanics behind drug delivery by nanoparticles by a thorough study and analysis of the literature, emphasizing the importance of formulation methods, size, and surface characteristics. This study also clarifies how pharmaceutical nanotechnology helps get beyond biological barriers including the mucosal and blood-brain barriers, making it easier to distribute medications to previously unreachable locations. We also go over current developments in the sector that are opening the door to precision and personalized medicine, such as stimuli-responsive nanocarriers and targeted delivery methods.

Key words: Nanotechnology, nanotubes, nanoparticles, liposome,

1. INTRODUCTION

Researchers have looked into nanotechnology as a new approach to medical research since it is the most promising technology of our day. Research and development on nanotechnology has increased over the last decade, suggesting that it will emerge in a new era of prosperity and production. Nanotechnology has the ability to boost economic growth and improve the capacity and quality of industrial sectors. It has greatly enhanced society's quality of life and influenced modern life. It has the capacity to fundamentally alter social dynamics, economic conditions, and human lives.Through the application of molecular tools and knowledge about the human body, technology and research have been utilised to diagnose illnesses, cure and prevent diseases, alleviate pain, and improve human fitness and quality of life. The majority of contemporary businesses employ nanotechnologies in medicine to deliver medications. Current medications are more bioavailable and more centred, and new forms of mobility could be introduced. Future uses of nanotechnology include multifunctional chemical systems for pharmaceutical shipment and illness, integrated sensory nano electronic systems, and nanoprobes. Nanoparticles are categorised as solid particles or particulate dispersions in the 10-1000 nm range. The drug has been attached to a matrix of nanoparticles, dissolved, encapsulated, or trapped. One can obtain nanoparticles, nanospheres, or nanocapsules based on the preparation method.

2. TYPES OF NANO SYSTEMS

2.1Liposomes

Liposomes are 400 nm-diameter, self-assembling, spherical, closed colloidal entities made of lipid bilayers encircling a central aqueous region. Liposomal formulations have been demonstrated to enhance the pharmacokinetics and

pharmacodynamics of related medications. A number of anticancer medications have been approved for use in liposome-based formulations to treat metastatic breast cancer and Kaposi's sarcoma.

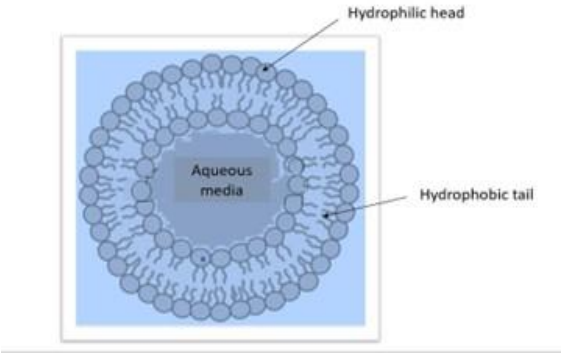

Figure 2.1 Structure of Liposomes

2.2 Dendrimers

A novel class of macromolecules known as dendrimers forms a three-dimensional spherical structure with a symmetrical center. These can be linked to medicinal substances or other physiologically active molecules because of their branching structure, which provides them with a large surface area. A chemical that recognizes cancer cells, a therapeutic substance that kills specific cells, and a molecule that recognizes cell death signals can all be found on a single dendrimer. It is claimed that dendrimers are designed to only release their contents when specific trigger molecules linked to cancer are present.

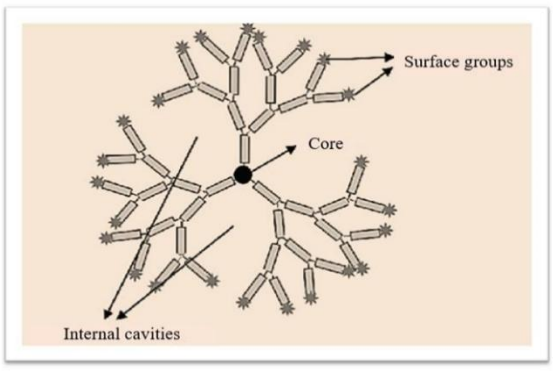

Fig. 2.2 Structure of Dendrimers

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2.3Carbon Nanotubes

A new type of carbon molecule surrounds them in the form of carbon nanotubes, which are hollow cylinders that can be as small as 0.7 nm in diameter and longer than several millimeters. A fullerene half molecule can be opened or closed at either end. Nanotubes are unique materials due to their small size as well as their remarkable mechanical, electrical, and physical characteristics. Despite weighing six times less than the finest steels, carbon nanotubes have a mechanical strength that is more than sixty times greater.

These frequently cover a very big area of the earth, have special electrical properties, are great heat conductors, and can be arranged in three dimensions. Their ability to absorb molecules is higher.

2.4 Quantum Dots

Tiny crystals known as quantum dots emit light when exposed to ultraviolet radiation. The latex beads containing these crystals release the color that highlights the interest sequence when they are triggered by light. As a spectral bar code, samples

that emit a discrete spectrum of colors and light intensities can be created by merging several quantity dots within a single bead. It is possible to create Latex beads packed with crystals that will bind to particular DNA sequences. The colors that the crystals release when they are activated by light serve as colors and highlight the sequences of interest.

2.5Polymeric nan-particles

These are colloidal carriers with sizes ranging from 10 nm to 1 µm, composed of either natural or synthetic polymers. Biocompatibility, non-immunogenicity, non-toxicity, and biodegradability are among the inherent properties of these nanoparticles that make them a viable substitute for the previously discussed nanosystems. Two varieties of polymeric nanoparticles are nanospheres and nanocapsules. The medication is dispersed throughout the polymer matrix in nanospheres, but it is confined within a cavity that is surrounded by a unique polymeric membrane in nanocapsules. Examples of natural polymers used in the production of nanoparticles include gelatin, albumin, and alginate. artificial polymers that are used to create nanoparticles One kind of synthetic polymer that might be utilised to create nanoparticles is preformed polymers.

2.5Polymeric Micelles

"Polymeric micelles," which are nanoscopic supramolecular core shell structures, are created when amphiphilic block copolymers combine. Usually less than 100 nm, their hydrophilic surface protects them from the reticulo-endothelial system's nonspecific pickup. Aggregates known as micelles form in liquids when the component molecules are arranged spherically. The hydrophobic core is shielded from water by a layer of hydrophilic groups. These are used to systemically give drugs that are insoluble in water. Moreover, drugs may be physically contained inside the hydrophobic cores of the micelle or covalently bound to the molecules that make up the micelle. These have a significant loading capacity, disintegrate more slowly, collect more medicine at the target location, and are stable under physiological circumstances.

3.PREPARATION OF NANOPARTICLES

Two factors are mostly taken into consideration while choosing the best technique for creating nanoparticles.

1. Physico chemical characteristic of polymer
2. Drug to be loaded

METHODSOF FORMULATION

1. Cross-linked amphiphilic macromolecule

Heat cross-linking b. Chemical cross-linking

2. Techniques based on polymerisation

The processes of dispersion polymerisation, interfacial polymerisation, interfacial complexation, monomer polymerisation, and emulsion polymerisation

3. Methods of polymer precipitation.

Methods of extracting or evaporating solvents, displacing solvents, and salting out

1.1 Cross linked Amphiphilic macro-molecules

Proteins, polysaccharides, and amphiphillic macromolecules are the materials utilized. These ought to be attracted to both lipid and aqueous solubility.

Aggregation occurs in either w/o or o/w emulsion types. The amphiphiles are subdivided by these before aggregative stabilization. Aggregation can also occur in an aqueous amphiphillic solution as a

result of solvent loss, extraction, and diffusion. Following their aggregation as microscopic particles, the amphiphiles undergo chemical cross-linking to become stiff.

3.2Polymerization based methods

The term "emulsion" Polymerisation is used to emulsify the monomer in an immiscible (non-solvent) phase using surfactants. But because this monomer dissolves in aqueous conditions, it acts as a precipitant for the later-synthesised polymer. For adsorptive loading in in-situ controlled polymerisation, the medication can be added to the monomeric phase or to the dispersion of the produced polymeric nanoparticles. The monomer is introduced into the dispersion medium of an emulsion or an inverted emulsion in a non-solvent-based polymeric solution. The polymerisation is initiated by the addition of a catalyst and proceeds through two phases: nucleation and growth (propagation).

However, since the nucleation is generated directly in the aqueous monomer solution, stabilisers or surfactants are not necessarily necessary for the formation of stable nanospheres in dispersion polymerisation. Biodegradable polyacrylamide and polymethyl-methacrylate (PMMA) nanoparticles are produced using this method.

3.2.1Interfacial polymerization

This process transforms the pre-formed polymer phase into an embryonic sheath. A volatile solvent is used to dissolve the polymer that will form the core and the medicine molecule that will be loaded. After that, the solution is placed in a non-solvent for the core phase and polymer. The polymer phase separates as a co-acervate phase at the o/w interphase. The mixture turns milky as a result of the formation of nanocapsules. This method encapsulates cells, proteins, enzymes, and antibodies.

3.2.2 Interfacial complexation

This is based on micro-encapsulation. The aqueous polyelectrolyte dissolves in reverse micelles in an apolar bulk phase with the help of an appropriate surface-active agent. When a competing polyelectrolyte is introduced to the bulk, a layer of insoluble polyelectrolyte complex may co-acervate at the interface.

3.3 Method of Polymeric precipitation

This procedure, which entails dissolving the hydrophobic polymer in a particular organic solvent and then spreading it in a continuous aqueous phase, renders it insoluble. The exterior phase also includes the stabiliser. They are sometimes referred to as solvent extraction or evaporation methods because of the solvent miscibility procedures. Evaporation or solvent extraction causes the polymer to precipitate.

3.3.1 Solvent extraction method

In this technique, a solvent that contains the stabilizer and a slightly water miscible solvent make a traditional o/w emulsion. The solvent extraction process may be modified in two ways: either by adding water to the system to affect the solvent's diffusion to the external phase (emulsification diffusion technique) or by removing the solvent afterwards (solvent evaporation method). The emulsification-diffusion technique has been used a lot lately in the solvent extraction process. The solvent used for the polymer, which is often weakly miscible with the dispersion phase, slowly diffuses and evaporates when the system is continually agitated.

3.3.2Solvent displacement method

This is based on the behaviour of a polymer at its interface following the removal of a water-miscible semi-polar solvent from a lipophilic solution. This method employs an organic phase that is fully soluble in the external aqueous phase, resulting in immediate polymer precipitation, because the two phases are totally miscible. Solvent extraction or separation is not necessary for polymer precipitation. The solvent is eliminated after the nanoparticles are formed, enabling the free-flowing nanoparticles to be produced at a lower pressure. For drugs that are just slightly soluble in water, this method works effectively. Drugs that are extremely hydrophilic diffuse into the external aqueous phase, while those that are very hydrophobic may precipitate as nanocrystals in the aqueous phase.

3.3.3 Salting out method

It is among the most widely used techniques for creating nanoparticles. A saturated aqueous solution of polyvinyl alcohol (PVA) is added to an acetone solution of the polymer while being stirred with a magnetic device to produce an o/w emulsion. Because the external aqueous medium in the nanoprecipitation technique is completely miscible with the polymeric solution (acetone), the process is different. Nevertheless, PVA saturation of the external aqueous phase in the salting out process stops the two phases from being miscible. The polymer precipitates when sufficient water is added to the external phase to allow the acetone from the internal phase to fully diffuse into the aqueous phase.

4 APPLICATIONS OF NANOPARTILES IN PHARMACEUTICAL INDUSTRY

Nanomedicine, a new discipline including a variety of diagnostic and therapeutic applications incorporating nanomaterials and nanodevices, has emerged as a result of recent advancements in nanotechnology. The primary goal of any novel therapeutic approach is to minimise the agents' toxicity or adverse effects by making them more sensitive to the target and, thus, lowering their dosage. Monitoring stem cell surface molecules, non-invasive tracking of in vivo transplanted stem cells and progenitor cells, stem cell delivery tracking systems, RNA interference (RNAi), and small stem cell differentiation drugs are all beneficial uses of nanotechnology in stem research. Nanotechnology is also used in the detection of poisons and bacteria.

4.1 Tissue Engineering

Applications for nanoparticles include implant coatings, bone repair, tissue regeneration, structural implant materials, bio-resourceable materials, implanted devices (such retinal implants and sensory aids), surgical instruments, operational tools, and smart instruments.

4.2 Carrier system of drug

Nanotechnology-enabled drug delivery systems offer better physical, chemical, and biological properties and can be employed as effective delivery methods for commercially available bioactives. Examples of nano-based carrier systems include polymeric micelles, dendrimers, liposomes, polymeric nanoparticles, polymer-drug conjugates, and antibody-drug conjugates. The following applications for the drug carrier system include targeted drug delivery, cancer treatment, gene therapy, and implantable delivery systems.

4.3 Biosensor

These tools are utilised to detect various pathogenic proteins and physiological-biochemical indicators associated with disease or aberrant metabolic processes in the body. A biosensor is a measurement tool that consists of a physiochemical detector component, a probe with a sensitive biological recognition element or bio-receptor, and a transducer to amplify and transform these signals into quantifiable form. A nanobiosensor, also known as a nanosensor, is a biosensor with dimensions on the nanoscale size scale. Biosensors are used for target identification, validation, and assay development.

4.4 Diagnostics

Gene expression, protein-protein interactions, signal transduction, and cellular metabolism are examples of subcellular biological processes that are shown, explained, and measured. Magnetic resonance imaging, optical imaging, nuclear imaging, and ultrasonic imaging all use them. Magnetic resonance imaging (MRI), fluorescence resonance energy transfer (FRET), multicolour multiplexing, dynamic imaging of subcellular structures, and selective labelling of cells and tissues are some further applications. MRI agents have been replaced by nanomaterials such magnetic nanoparticles, dendrimer, quantum dots, and carbon nanotubes.

4.5 Drug Discovery

Nanotechnology helps with target identification and validation by identifying the protein on the target surface. By increasing the scalability, automation, and reliability of tests, nanotechnology will enhance the drug delivery process. Single-walled nanotubes are an effective way to identify the pathogen's surface protein. Individual glycine receptors are tracked and their motions inside the neuronal membrane of live cells are examined using quantum dots for periods ranging from milliseconds to minutes. Gold nanoparticles and ablynx-produced nanobodies, the smallest, most accessible, complete antigen-antibody fragments, are often used nanomaterials in diagnostics.

4.6 Gene Therapy

The disease-causing aberrant gene is replaced with the normal gene using a carrier molecule. Nanotechnology has enabled a potential and effective method for systemic gene therapy. Modified silica nanoparticles, poly-1-lysine, gelatin, and chitosan are all used in gene therapy. These have enhanced transfection efficiency and decreased cytotoxicity. The most effective vectors for gene delivery are provided by nanotechnology.

5 CONCLUSION

Pharmaceutical nanotechnology provides new tools for studying cells and distinguishing between normal and aberrant cells, it has a significant impact on attempts to prevent disease. It might provide information about the molecular causes of illness.Pharmaceutical nanotechnology has become a field with great promise for delivering bioactives and diagnostics in both space and time, as well as for producing intelligent materials for tissue engineering. Numerous facets of illness, diagnosis, prognosis, and treatment are expected to be significantly impacted by the additional tools, opportunities,

and scope that its nano-engineered technologies offer.

Pharmaceutical nanotechnology has opportunities to create new technologies and improve materials and medical equipment in fields where more conventional and established technologies may be nearing their limitations. It provides the industry fresh hope by providing new patentable technology in reaction to the loss of revenue from off-patent pharmaceuticals.

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