A REVIEW ON NANOTECHNOLOGY IN VIROLOGY

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Abstract: -

Infectious diseases are the leading cause of mortality worldwide, with viruses in particular making global impact on healthcare and socioeconomic development. In addition, the rapid development of drug resistance to currently available therapies and adverse side effects due to prolonged use is a serious public health concern. The development of novel treatment strategies is therefore required. The interaction of nanostructures with microorganisms is fast-revolutionizing the biomedical field by offering advantages in both diagnostic and therapeutic applications. Nanoparticles offer unique physical properties that have associated benefits for drug delivery. These are predominantly due to the particle size (which affects bioavailability and circulation time), large surface area to volume ratio (enhanced solubility compared to larger particles), tunable surface charge of the particle with the possibility of encapsulation, and large drug payloads that can be accommodated. These properties, which are unlike bulk materials of the same compositions, make nano particulate drug delivery systems ideal candidates to explore in order to achieve and/or improve therapeutic effects. The development of nanotechnology is a multidisciplinaryactivity involving fundamentalfeasibility. Various new delivery systems such as nanotraps, nanorobots, nanovesicles, nanofibers, and nano diamonds are paving the way for the diagnosis, prevention, and treatment of viral infections. These systems expanded our vision and opened a whole new area of research in the field ofantiviral drugs. Nanotechnologyis amoderntechnologywidelyused in variousfields of medicine, including drug delivery, gene therapy, antimicrobial agents, biosensors, and biomarkers. Nanoparticles play an important role as an anti-infective agent and thus act as effective antiviral agents.

Index Terms: -

Nanoparticle Infectious Diseases, encapsulation, nanotraps, nanorobots, nanovesicles, nanofibers, anti-infective.

I. INTRODUCTION:

Infectious agents such as bacteria, viruses, fungi and parasites cause approximately 15 million deaths worldwide, with acute respiratory infections and human immunodeficiency virus (HIV) being the leading causes. Viral infections alone represent major global health problems affecting millions of people worldwide, with negative effects on both health and socioeconomic development. Effective treatment of viral infections is hampered by the development of drug resistance, especially to hiv and influenza. This phenomenon poses a threat to public health, including increased morbidity and mortality, additional costs associated with the use of more expensive drugs, and an increased burden on public health systems. Thus, there is an obvious need to develop new methods to treat viral infections.

Nanotechnology refers to the development or use of particles with dimensions in the nanometer range (10-9 or billionths of a meter). The interaction of nanoscience and biological systems is known as "Nano biotechnology", while the related "nanomedicine" deals with the application of nanostructured materials for the diagnosis, treatment and prevention of diseases. Viral nanoparticles (VNPs) are virus-based nanoparticles that can be used as building blocks for new materials with different properties. VNPs can be bacteriophages, plant or animal viruses and can be infectious or non-infectious.

The first Nano systems used in medicine were introduced to increase the effectiveness of current but dose-limiting and poorly bioavailable drugs. Nanoparticles can now exert their antiviral effects through several different mechanisms. Nanoparticles have unique properties such as (1) small particle size (which can facilitate drug delivery to anatomically preferred sites), (2) high surface area/volume ratio (which ensures uptake of large amounts of drugs), and (3) tunable. Surface charge (to facilitate cellular access through a negatively charged cell membrane) makes nanoparticles attractive tools for viral therapy. Finally, it is believed that drug delivery can be greatly improved by designing nanoparticles with targeting moieties to increase specificity for desired cell types, target tissues, or subcellular compartments.

This review provides an overview of the recent and relevant literature describing the application of nanotechnology in the treatment of common viral infections.

ADVANTAGES:

- Fairly easy preparation.
- Targeted and drug delivery.
- Due to their small size Nanoparticles penetrate small capillary and are taken up by the cell which allows for efficient drug accumulation at the target sites in the body.
- Good control over size and size distribution.
- Good protection of the encapsulated drug.
- Retention of drug at the active site.
- Longer clearance time.
- Increased therapeutic efficacy.
- Increased bioavailability.
- Dose proportionality

DISADVANTAGES:

- Extensive use of polyvinyl alcohol as a detergent –issues with toxicity.
- Limited targeting abilities.
- Discontinuation of therapy is not possible.
- Cytotoxicity.
- Pulmonary inflammation and pulmonary carcinogenicity.
- Alveolar inflammation.
- The disturbance of autonomic imbalance by nanoparticles having direct effect on heart and vascular function.

II. THERAPEUTIC APPLICATIONS OF NANOFORMULATION:

Nanoparticles with different compositions and characteristics and investigated for various therapeutic applications as follows: -

- Carriers of drugs and biological agents
- Carriers of gene and DNA
- Carriers of antigens & vaccines
- Controlled & targeted drug delivery
- Carriers of diagnostic agent
- Carriers of MRI contrast

Nano medicine is a subset of nanotechnology, which uses tiny particles that are more than 10 million times smaller than the human body. In nanomedicine, these particles are much smaller than the living cell. Because of this, Nano medicine presents many revolutionary opportunities in the fight against all types of cancer, neurodegenerative disorders and other diseases.

III. VIRUS AS NANOCARRIERS:

Viruses have naturally evolved to infect certain host cells very efficiently. And delivers its cargo of genetic material. Viruses thus provide an ideal basis for the development of targeted drug delivery vehicles or tissue-specific imaging reagents. VNPs can be considered as one of the most advanced and versatile nanomaterials produced by nature. They serve as versatile tools for medical applications. Genetically modified VNPs are used as vaccines.

Chemically modified: VNPs are used in targeted drug delivery and biomedical imaging. Virus nanoparticle (VNP) is an important class of bio-inspired nano systems. These self-assembled supramolecules can be used to develop nanocarriers and nanomaterials. Viral proteins have ideal properties such as biocompatibility, biodegradability, inherent monodispersity, uniform size distribution and chemically modifiable for various functional functions. Because they are easy to produce with high precision and enable the encapsulation of therapeutic agents in high concentrations within the protein shell, VNPs can be mass produced.

A subset of VNPs are Virus like Particles (VLPs) which are non-infectious proteins because they lack the viral genome and can spontaneously assemble into a cage-like structure. VLPs can be used to deliver targeted drugs, siRNAs, RNA aptamers, proteins, peptides, etc. The VPN of plant virus consists of protein coats that contain the nucleic acid, which virus needs to replicate in plants. The main advantage of using VNPs derived from plant viruses is that they are not infectious to humans and mammals because they are host-specific. Plant virus VPN consists of protein layers that contain the nucleic acid the virus needs to replicate in plants. An important advantage of using VNPs derived from plant viruses is that they are non-infectious to humans and mammals because they are host-specific. Some such naturally occurring virus-based nanocarriers include: Bovine mosaic virus, Tobacco mosaic virus (TMV), Red clover necrosis mosaic virus (RCNMV), bacteriophages.

IV. CONCEPT FOR TARGETED DRUG DELIVERY:

Plant viral nanoparticles have the potential to revolutionize cancer treatment and drug targeting by creating nanoparticles that are cell-specific with very low side effects. Viral nanoparticles could potentially carry high drug payload with higher cell efficacy than traditional current available treatments.

V. STEPS INVOLVED IN VIRAL VACCINE PRODUCTION:-

- Selecting strain for vaccine production.
- Growing microorganism.
- Isolation and purification of microorganism.
- Centrifugation
- Filtration
- Chromatography
- Inactivation of organism
- Formulation vaccine
- Quality tests and lot release

VI. RECENT STUDIES IN NANOTECHNOLOGY:

This new branch of nanoscience or nanotechnology seems to be emerging. This branch is characterized by the application of preparation methods and/or the diagnostic tools developed in nanoscience/nanotechnology in order to perform either new, decisive experiments or to open the way to novel applications in areas of science that were originally not related to Nanoscience/nanotechnology, such as cancer research or quantum physics. In order to highlight the diversity of this new branch, we shall discuss the following four areas in which methods of Nano science /nanotechnology are applied to other areas of science:

(1) Cancer therapy,

(2) Cellular labeling,

(3) The synthesis of solid materials with tunable atomic structures, and

(4) The new opportunities provided by nanoscience/nanotechnology to probe the limits of quantum physics, one of the classical problems of physics.

Recently, the combination of nanotechnology and human natural stem cell-based therapies has led to emergence of new strategies in treatment of various deceases. For example, “LIFNano” (Leukaemia inhibitory factor nano formulation), a synthetic stem cell product with the current indication in multiple sclerosis (MS) and rheumatoid arthritis, has attracted much interest in the management of COVID-19 pneumonia. The surface ligands of COVID-19 have also attracted the attention of Nano Viricides company to develop a nano formulation based on an viricide® technology. Nano viricide, an antiviral polymeric nano micelle-based formulation for influenza, HIV, herpes, etc., comprises a single-chain polymer conjugated to specific ligands that help in engulfing or coating the virus, resulting in virus neutralization and destabilization and may be viral genome attacking. Taken together, nanotechnology-based antiviral materials might be promising options for the treatment of CoV infections. Further experiments are, however, necessary to assess their safety and efficacy.

VII. FUTURISTIC ASPECTS:

Various novel delivery systems like nano traps, nanorobots, nanobubbles, nanofibers, and nano diamonds are paving their way in the diagnosis, prevention, and therapeutics of viral infections. These systems have broadened our vision and opened up a whole new area of research in the direction of antiviral therapeutics. It is identified that the manufacturing process is highly complicated process which involves the use of complex procedures, high exposure, and complex machinery. Due to large advantages of the nano forms, many new researches are going on in the present day to incorporate newer drugs via the system, It also provides clinicians an opportunity to offer more therapeutic options to their patients to optimize their care. Types of nanoparticles include; Nano traps, Nanobubbles, Nano shells, polymers, nanosuspension, nano emulsions etc.

Mathematical modeling in the treatment of viral diseases

SL.NO	Type of nanoparticle	Material used	Application
1	Nano suspensions and Nanocrystals	Drug powder is dispersed in surfactant solution.	Stable system for controlled delivery of poorly soluble drug
2	Magnetic Nanoparticles	Magnetite Fe2O3, Meghe Mite coated with dextran	Drug targeting diagnostics to in medicine
3	Carbon Nanotubes	Metals, semiconductors	Gene and DNA delivery
4	Nanoshells Ceramic	Dielectric core and metal shell	Tumor targeting
5	Ceramic Nanoparticles	Silica, alumina, titanium	Drug and biomolecule delivery
6	Aerogel	Nanopores which is produced by cell gel chemistry	Nanoparticles Controlled release drug carriers.
7	Quantum dots	cdSe-cdS core shell	Targeting ,imaging agent
8	Nano wires	Silicon, cobalt, gold	Transport electron in nano Electronics.

VIII. CONCLUSION:

In this work, I have tried to provide information about the manufacturing techniques as well as the instruments used in the formation and evaluation of various dosage forms in the large-scale pharmaceutical industry. It is identified that the manufacturing process is highly complicated process which involves the use of complex procedures, high exposure, and complex machinery. Nanoparticles represents promising drug carrier for various drug delivery systems Nanotechnology is breakthrough technology pervading all fields newer applications of this field are being explored worldwide. Nanoparticles represents a technology to overcome solubilities and bioavailability problems of drugs which can be generally applied to all poorly soluble drugs. Any drug can be transformed to drug nanoparticles leading to increasing saturation solubility, dissolution rate and providing in general feature of an increased adhesiveness to surfaces. Nano particulate drug delivery system is increasingly viewed as an advantageous solution for biological drugs. In addition, nanoparticles provide efficient treatment by enabling targeted and controlled release thus in feature Nano particulate drug-delivery system seem to be a viable and promising strategy for the biopharmaceutical industry.

Nano viricide, an antiviral polymeric nano micelle-based formulation for influenza, HIV, herpes, etc., comprises a single-chain polymer conjugated to specific ligands that help in engulfing or coating the virus, resulting in virus neutralization and destabilization and may be viral genome attacking. Taken together, nanotechnology-based antiviral materials might be promising options for the treatment of CoV infections. Further experiments are, however, necessary to assess their safety and efficacy. Ultimately, nanotechnology provides several interesting systems to promote the fields of CoV prevention, treatment, and diagnosis.

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