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Review Article

A Review on Nanoparticles Drug Delivery System

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Abstract

The method or process of delivering a pharmaceutical ingredient to create a therapeutic effect in people or animals is referred to as drug delivery. Nasal and pulmonary routes of medication administration are becoming increasingly important in the treatment of human illnesses. These methods, especially for peptide and protein therapies, provide potential alternatives to parenteral drug administration. Several medication delivery methods have been developed for this purpose and are being tested for nasal and pulmonary delivery. Chitosan, Alginate, vanilline oxalate, zinc oxalate, cellulose, polymeric micelles, Gliadin, and phospholipid are examples of these. Multidrug resistance, a key issue in chemotherapy, can be reversed with these nanoparticles. Surgery, chemotherapy, immunotherapy, and radiation are all well-established treatments used in cancer treatment. A nanoparticle has emerged as a potential method for the targeted delivery of medicines used to treat certain illnesses.

Keywords: Nasal Drug Delivery, Pulmonary Drug Delivery, Nanoparticles

Introduction

The main aims of nanoparticle design as a delivery system are to regulate particle size, surface characteristics, and release of pharmacologically active substances in order to produce site-specific drug activity at the therapeutically appropriate rate and dosage regimen.[1] Despite the fact that liposomes have been used as potential carriers with unique advantages such as protecting drugs from degradation, targeting to site of action, and reducing toxicity or side effects, their applications are limited due to inherent problems such as low encapsulation efficiency, rapid leakage of water-soluble drugs in the presence of blood components, and poor storage stability, their applications are limited.[2] Polymeric nanoparticles, on the other hand, have certain distinct benefits over liposomes. They can assist enhance the stability of drugs/proteins, for example, and have valuable controlled release qualities. Understanding the pharmaceutically relevant characteristics of nanoparticles is critical for improved development of nanoparticulate systems.[3] In recent years, there has been a lot of interest in using nanoparticles as a drug/gene delivery method. Nanoparticles are colloidal particles with diameters ranging from 10 to 1000 nm that are made from biodegradable polymers and can contain, adsorb, or chemically link a medicinal substance.[4]

Vanillin oxalate nanoparticle [Anti-oxidant]

Because the buildup of hydrogen peroxide (H2O2) causes oxidative stress, H2O2 might be used as a biomarker for a variety of oxidative stress-related inflammatory illnesses. Vanillin, one of the most important components of natural vanilla, is an antioxidant and anti-inflammatory agent.[5] In this study, we created poly(vanillin oxalate), a new inflammation-responsive antioxidant polymeric prodrug of vanillin (PVO). PVO's backbone has acid-responsive acetal linkages that integrate H2O2-reacting peroxalate ester bonds and bioactive vanillin.[6] PVO rapidly breaks into three harmless components in cells damaged by oxidative stress, one of which is antioxidant and anti-inflammatory vanillin. PVO nanoparticles have powerful antioxidant properties, scavenging H2O2 and suppressing the production of reactive oxygen species (ROS), as well as lowering the expression of pro-inflammatory cytokines in activated macrophages in vitro and in vivo.[7] As a result, we believe PVO nanoparticles have a lot of potential as new antioxidants and medication delivery methods for ROS-related inflammatory disorders.[8]

Nanoparticles of chitosan

The advancements gained in ocular delivery of bioactive compounds using chitosan-based nanosystems, as well as their clinical relevance The research shows that chitosan-based nanostructures are adaptable systems that may be customized to meet specific compositions, surface properties, and particle sizes.[9] The formulation circumstances of the nanotechnologies responsible for their production, the incorporation of other materials in the preparation processes, and/or the use of synthetically modified chitosan are all known to impact their in vivo performance.[10] Furthermore, this study demonstrates how

advancements in our understanding of nanosystems' interactions with ocular structures could logically lead to difficult developments in ocular nanomedicines in the next years, with a major influence on clinical practice.[11]

Cellulose nanoparticles

Among the United States, prostate cancer (PC) is the most often diagnosed illness in males. Curcumin (CUR), a naturally occurring diphenol, has been found to have significant anti-cancer properties in a variety of malignancies. However, its effectiveness in cancer treatments is limited by its low bioavailability and inadequate pharmacokinetics.[12] There have recently been some successful CUR nanoformulations described that enhance on these characteristics; nevertheless, there is no customized safe nanoformulation for prostate cancer. Two key scientific elements of prostate cancer treatments are addressed in this work.[13] In prostate cancer cells, the initial goal was to compare the cellular uptake and cytotoxicity of -cyclodextrin (CD), hydroxypropyl methylcellulose (cellulose), poly(lactic-co-glycolic acid) (PLGA), magnetic nanoparticles (MNP), and dendrimer-based CUR nanoformulations.[14] In prostate cancer cells, curcumin-loaded cellulose nanoparticles (cellulose-CUR) had the highest cellular absorption and induced the most ultrastructural alterations linked to apoptosis (presence of vacuoles). Second, cell proliferation, colony formation, and apoptosis (7-AAD staining) tests were used to assess the anti-cancer potential of the cellulose-CUR formulation in cell culture models.[15] When compared to free curcumin, the cellulose-CUR formulation demonstrated enhanced anti-cancer effectiveness. For the first time, our research demonstrates the viability of cellulose-CUR formulation and its prospective application in prostate cancer treatment.[16]

Alginate nanoparticles

An alginate nanoparticle was created to test the pharmacokinetics and tissue distribution of free and alginate-encapsulated antitubercular medicines in mice at various dosages. Controlled cation-induced gelification of alginate yielded nanoparticles encapsulating isoniazid (INH), rifampicin (RIF), pyrazinamide (PZA), and ethambutol (EMB).[17] Mice were given two dosage levels of the formulation orally (D1 and D2). In mice given free medicines at comparable dosages, a comparison was performed. High-performance liquid chromatography was used to examine the drugs (HPLC).[18] Alginate nanoparticles had an average size of 235.5 0.0 nm and a polydispersity index of 0.44; drug encapsulation was 70–90% for INH and PZA, 80–90% for RIF, and 88–95% for EMB. The D1 group (per body surface area of mice) had greater RIF and INH plasma levels and lower PZA and EMB plasma levels in the free drug groups than the D2 group (per body surface area of mice) (recommended human dose).[19] In the D1 encapsulated group, all drug plasma levels were greater than in the D2 encapsulated group, resulting in larger values of the area under the plasma drug concentration–time curve (AUC0–). All medicines encapsulated in alginate nanoparticles have considerably greater relative bioavailabilities than free drugs. After administration of encapsulated medicines, drug levels remained at or above the minimum inhibitory concentration (MIC90) in organs until Day 15, but free drugs persisted at or above the MIC90 only up to Day 1 regardless of dosage.[20] Drug levels in numerous organs remained above the MIC for the same amount of time at both dosages, showing their equi-efficiency. Alginate nanoparticles have a lot of promise for decreasing antitubercular medication dosage frequency.[21]

Polymeric micelles nanoparticle

A variety of formulation strategies for targeting medicines to particular locations have been documented in the literature. Both passive and active methods can be used to target polymeric micelles (PMs) to tumor locations. PMs' intrinsic features, such as nanoscale size, plasma stability, in vivo lifetime, and tumor pathological characteristics, allow them to be targeted to the tumor site through a passive process known as the increased permeability and retention effect.[22] PMs made from an amphiphilic block copolymer can be used to encapsulate anticancer medicines that are poorly water soluble and hydrophobic. Other features of PMs, such as distinct functioning at the outer shell, are beneficial for actively directing anticancer drugs to tumors. To target micelles to cancer cells, PMs can be conjugated with a variety of ligands, including antibody fragments, epidermal growth factors, 2-glycoprotein, transferrin, and folate.[23] Alternative ways for increasing drug accumulation in tumoral cells include the use of heat or ultrasound. Micelle-based targeting can also be used to target tumor angiogenesis, which is a promising target for anticancer medicines. In preclinical and clinical trials, PMs have been utilized to deliver a variety of anticancer medicines. This study covers the most recent knowledge on utilizing PMs to target anticancer medicines to the tumor location.[24]

Gliadin Nanoparticles

By restoring T-cell tolerance to gliadin, Celiac disease might be treated and possibly cured. In three animal models of celiac disease, the safety and effectiveness of negatively charged, 500 nm poly(lactide-co-glycolide) nanoparticles encapsulating gliadin protein (TIMP-GLIA) were studied. In other animal models of autoimmune illness, the uptake of these nanoparticles by antigen-presenting cells was found to promote immunological tolerance. HLA-DQ8, huCD4 transgenic Ab0 NOD mice. C57BL/6, RAG1–/– (C57BL/6), and HLA-DQ8, huCD4 transgenic Ab0 NOD mice.[25] Mice received one or two injections of TIMPGLIA or control nanoparticles into their tail veins. Intradermal injections of gliadin in full Freund's adjuvant (immunization), soluble gliadin, or ovalbumin were administered to certain animals (ear challenge). RAG–/– animals were given intraperitoneal injections of CD4+CD62L–CD44hi T cells from gliadin-immunized C57BL/6 mice, and were administered an AIN-76A-based diet with or without gluten (oral challenge).[26] Proliferation and cytokine secretion assays, as well as flow cytometry, RNA sequencing, and real-time quantitative PCR, were used to examine spleen or lymph node cells. Gliadin antibody ELISA was used to evaluate serum samples, and histology was used to examine intestinal tissues. TIMP-GLIA, anti-CD3 antibody, or LPS (controls) were grown in media containing human PBMC or immature dendritic cells generated from human PBMC and evaluated in proliferation and cytokine secretion assays or flow cytometry. TIMP-GLIA was used to incubate whole blood or plasma from healthy participants, and hemolysis, platelet activation and aggregation, and complement activation or coagulation were all measured.[27]

Phospholipid nanoparticles

Nanotechnology is gaining popularity as a means of successfully delivering therapeutic medicines to the cardiovascular system. A novel, effective, and efficacious strategy for treating different cardiac diseases such as atherosclerosis, hypertension, and myocardial infarction is nanocarrier-based medication delivery to the heart. The difficulties associated with conventional drug delivery methods, such as nonspecificity, severe side effects, and

harm to normal cells, are avoided using nanocarrier-based drug delivery systems.[28] Changes to nanocarriers' physicochemical qualities, such as size, shape, and surface modifications, can drastically affect their invivo pharmacokinetic and pharmacodynamic data, resulting in a more effective treatment strategy. Several nanocarriers have been created for delivering medicines to specific locations within the heart, including lipid and phospholipid nanoparticles. This study reviews and expands knowledge of sophisticated nanosized medication delivery systems for the treatment of cardiovascular diseases using nanotechnology.[29]

Zinc oxide nanoparticles

The etiology of illnesses such as atherosclerosis, rheumatoid arthritis, asthma, and cancer is heavily influenced by inflammation. The lack of anti-inflammatory medicines and vectors necessitates the development of novel compounds to treat inflammatory diseases. Because of its superior characteristics to bulk equivalents, nanotechnology has developed as a fantastic research field in the last decade. [30] The green production of zinc oxide nanoparticles (ZnO NPs) and different characterization techniques used to understand the physiochemical characteristics of nanoparticles are discussed in this study. The interaction of ZnO NPs with cells as well as their pharmacokinetic behavior inside the cells has been explored.[31] The mechanism-based method was used to investigate the anti-inflammatory effects of ZnO NPs. A brief overview of the literature has been given, which outlines the size, shape, and inflammatory model used to assess ZnO NPs' anti-inflammatory efficacy. The potential of ZnO NPs for anti-inflammatory action, such as their stable nature and selective targeting, has been briefly explored. The current work shows ZnO NPs' potential as an anti-inflammatory therapeutic molecule or a drug delivery vector.[32]

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