

REVIEW ADVANCEMENT IN NOVEL DRUG DELIVERY SYSTEM

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Abstract

Plants are nature's way of helping people and have been used by humans for a long time for food and medicine. Today, there's a big movement around finding medicines from plants and bringing them to the market using special ways to deliver the drugs. The idea is that the cure for every disease can be found in nature. However, delivering these herbal medicines also needs some changes to make them work better, like making them release slowly, helping patients take them regularly, and more. In the past, herbal drugs didn't interest scientists much because it was hard to process, standardize, extract, and identify them. But now, with better technology, new ways to deliver drugs are opening up possibilities for making herbal medicine more effective. Using advanced techniques, it's possible to protect the medicine from becoming harmful, improve its stability, and make it easier for the body to use. These new drug delivery methods are important for making herbal medicines work better and reduce harmful effects. This review provides information about different new techniques used to improve the safety and effectiveness of plant-based medicines and how new formulations are applied. The main aim of developing these systems is to reduce drug loss, avoid harmful side effects, and make the medicine more available in the body. Targeting is the ability to send the medicine directly to where it's needed. Some examples of drug carriers include soluble polymers, microparticles made from insoluble or biodegradable natural and synthetic materials, microcapsules, cells, cell ghosts, lipoproteins, liposomes, and micelles. There are two main ways to direct the medicine to the right place: passive targeting and active targeting. Controlled drug delivery systems, such as micellar solutions, vesicles, and liquid crystal dispersions, as well as nanoparticle dispersions that are small particles ranging from 10 to 400 nanometers, show a lot of promise as drug delivery systems. Hydrogels are three-dimensional, water-loving polymer networks that can absorb a lot of water or bodily fluids.

KEYWORDS : New drug delivery system, Phytosome, Nanoparticles, Microsphere, Transdermal Drug Delivery System Carriers, Colloidal drug carriers.

INTRODUCTION

Herbal formulation refers to a form of medicine that includes one or more herbs or prepared herbs in certain amounts to offer specific health, beauty, or other benefits. Herbal preparations are made by using whole plants, parts of plants, or broken pieces of plants and treating them with methods like distillation, extraction, pressing, separating, cleaning, thickening, or fermenting. These preparations can be in the form of crushed or powdered herbs, tinctures, extracts, essential oils, pressed juices, and processed plant secretions. Herbal medicines are made up of many active ingredients that work together in a way that increases their effectiveness. Herbal medicines usually have fewer side effects.

ects compared to some other types of medicines.

Novel drug delivery systems can be based on physical methods or biochemical methods. Physical methods, also called controlled drug delivery systems, work through ways like osmosis, diffusion, erosion, dissolving, and using electricity to move the medicine. Biochemical methods include things like monoclonal antibodies, gene therapy, using vectors, linking drugs with polymers, and using liposomes. Targeting means delivering the medicine to the right place in the body. There are two main ways to control when and where the medicine is released: passive targeting and active targeting.

Some new drug delivery systems offer benefits such as making the medicine work longer, reducing how often it needs to be taken, controlling where it goes in the body, and keeping the right amount of medicine in the body over time.

Aim and Objectives

Aim: To review and analyze recent advances in novel drug delivery systems for improved therapeutic efficacy and patient compliance.

Objectives:

1. To study nanocarrier-based systems (liposomes, micelles, dendrimers, nanoparticles).
2. To explore targeting mechanisms (passive, active, stimuli-responsive).
3. To assess extended release strategies for long-term therapy.
4. To understand the role of microfluidics in carrier fabrication.
5. To identify future challenges and opportunities in NDDS.

Molecular imprinting technology:

Molecular imprinting technology has a big potential for making good drug dosage forms. This process starts by making a prepolymer complex between a template molecule and functional monomers or oligomers. These functional molecules are designed to interact with the template either through covalent bonds, non-covalent bonds, or both. Once this complex is made, a polymerization reaction happens with the help of a cross-linking monomer and a suitable solvent. The solvent and cross-linker control the shape and structure of the final polymer. After the template molecule is removed, the resulting material is a polymer with special parts that can recognize and bind the original template molecule. Some examples of drug delivery systems that use molecularly imprinted polymers include: (i) systems that release drugs at a controlled rate, (ii) systems where drug release is triggered by some physical, chemical, or biological process, and (iii) systems where drug release is controlled based on the level of a certain substance in the body, like a biochemical marker that changes with drug concentration.

ADMINISTRATION ROUTES:

The way a drug is given depends on how well patients accept it, the nature of the drug (like how well it dissolves),

how easy it is to get to the affected area, and how well it works for the disease. The most common way to give drugs is by mouth, called the peroral route. More and more drugs are made from proteins and peptides, which can be really effective. But these drugs have some challenges. They don't pass through mucous membranes or biological barriers easily, and they can be broken down or destroyed quickly in the liver and other parts of the body. They also need exact dosing. Right now, most protein drugs are given by injection, but this method isn't always comfortable and can lead to changes in drug levels in the blood. Even though the digestive system presents challenges like acid in the stomach breaking down the drug, enzymes in the gut breaking it up, and bacteria in the colon changing it, the peroral route is still the most studied. This is because it's easier for patients, cheaper to use, and can reduce the cost of making the drug.

Carrier Based Drug Delivery System

"Nanotechnology" was first talked about in 1959 and is now growing quickly in science and industry. It's combining with biotechnology, information technology, and cognitive science to change the life sciences field a lot. Nanotechnology has special physical, chemical, and biological features, and the new nano products are expected to be used a lot in the medical field. Using nanotechnology to build drug delivery systems can help improve drug solubility, stability, and targeting of tumors, and also reduce harmful side effects. Many different materials are used to make these nano drug delivery systems, such as liposomes, nanodrug polymer micelles, hydrogels, and inorganic nanodrug delivery systems.

Liposomes

Liposomes are tiny, bubble-like structures made from layers of fat molecules. These layers form a shell that is not water-soluble and a center that is water-soluble. Their size ranges from 20 to 1000 nanometers. Because of their special structure and makeup, liposomes are safe for the body and can be broken down normally. They help improve how well drugs dissolve in the body and can reduce harmful effects of drugs. Liposomes can hold both water-soluble and fat-soluble drugs, which helps protect the drugs from breaking down and prevents them from building up in other parts of the body. The use of liposomes in drug delivery, based on nanotechnology, has taken almost 50 years to be used in real medical treatments. This has led to major progress in making better medicines for cancer, infections, and vaccines. For example, when resveratrol, a cancer drug, was delivered using solid lipid nanoparticles, it showed a much higher concentration in the brain of Wistar rats compared to when it was used without the nanoparticles. This shows that the drug can better reach brain tumors and has less harmful effects on the whole body. In treating cancer, liposomes that carry radiation-sensitive drugs can make X-ray treatment more effective. Zhao and their team created a special type of liposome called an antigen-capturing stapled liposome (ACSL) that can collect and carry tumor-related proteins from inside cells to the outside, which helps the immune system better recognize and fight cancer. Liposomes that carry the cancer drug doxorubicin have been found to reduce heart damage and other side effects like loss of hair, tiredness, and nausea. Research also shows that using nanoliposomes to deliver decoquinate, a drug used against parasites, greatly improves its effect.

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Tocosome

Tocosome is a complex system that uses tiny, bubblelike structures to carry active ingredients. It mainly contains alpha-tocopherol phosphate (TP), which is a type of vitamin E. Vitamin E has eight different forms, but alpha-tocopherol is the most common and effective one. TP is special because it has a uniform size, can efficiently hold drugs, causes little reaction in the body, is safe to use, and can dissolve and move through the body well. These features help it stay stable for longer. Tocosomes are similar to liposomes, which are made from molecules that have both water-loving and water-repelling parts. They form a layer that can hold substances, and they work in a similar way to deliver and release drugs, even though their chemical makeup is different. Studies have shown that TP has many health benefits, such as helping prevent heart disease, protecting the heart, reducing inflammation, and stopping cancer from spreading. In addition to TP, Tocopherol formulations often use different mixtures of phospholipids and cholesterol to help pack and control the release of medicines like 5-fluorouracil, which is used in cancer treatment.

Polymer Nanoparticles

Polymer nanoparticles are tiny particles made from different types of polymers. These particles range in size from 10 to 1000 nanometers. Larger particles have trouble passing through the blood vessels or the blood-brain barrier, but smaller polymer nanoparticles can move through these barriers more easily to reach the intended area in the body. Some common types of polymer nanoparticles include synthetic materials like polylactic acid, PLGA, polyamino acids, and natural ones like chitosan, alginate, gelatin, and albumin. These nanoparticles help in reducing harmful effects on the body, keeping drugs stable for longer, improving how drugs are released, and making them safer and more effective. Changing how the polymer breaks down or bonds can also control when and how the drug is released in the body and help remove the delivery system more easily. Adding polyethylene glycol (PEG) to the surface of the nanoparticles makes them stay longer in the bloodstream and helps them gather more in areas with damaged blood vessels. A new strategy has been developed that uses near-infrared (NIR) light to remove PEG and present certain molecules, which is done by breaking down azo bonds that are temperature-sensitive. This method uses doxorubicin along with other substances made from long PEG chains connected by these sensitive bonds. The nanoparticles assemble to create a system that can deliver the drug effectively when exposed to mild heat. This process helps the nanoparticles to build up in tumors, control how the heat affects the drug release, and use the heat to trigger the release of the medicine. Van De Ven and others used PLGA as a base and amphotericin B as the drug to make nanoparticles, which showed no serious red blood cell damage in lab tests and

were safe and effective against fungal infections. One of the major challenges in medicine is getting drugs past the blood-brain barrier to treat conditions in the brain. A promising approach is using special nanoparticles that can cross the blood-brain barrier and deliver drugs to specific areas in the brain.

Polymer Micelle

Polymer micelles are commonly used and are made when amphiphilic block copolymers come together in water. These micelles have a strong structure, can dissolve hydrophobic drugs, and are not very harmful. They are between 10 to 100 nanometers in size, which helps them avoid being taken up by the body's immune system, allowing them to stay in the bloodstream longer. The outer layer of the micelles is water-loving, which stops the drug from leaking out in the blood and also stops the body's complement system from removing the drug too early. In the past thirty years, polymer micelles have been widely used to carry small molecule drugs that are very strong, very harmful, and not very soluble in water.

In antifungal treatments, Albayaty and others created a micellar system that responds to changes in acid and base levels. This system is good at holding the drug itraconazole, which works well against *Candida albicans* biofilms, making it less active. Polymer micelles can also carry several chemotherapy drugs at once, targeting tumors specifically. This can lower side effects from chemotherapy and improve the survival and quality of life for people with pancreatic cancer. This is a big step forward for treating cancer. Zhang and others developed micelles called Cela/GCTR that are very promising for delivering hydrophobic anticancer drugs to treat liver cancer. These micelles slowly release the drug in the blood but release it quickly once they reach the tumor. The hydrophobic parts of the micelles are in the center, holding the drug, while the hydrophilic parts are on the outside, keeping the micelle stable in water. By adding certain molecules to the outside, these micelles can cross the blood-brain barrier through a process called transcytosis and release their medicine inside the cells. Several types of block copolymer micelles, like PAA-PEG, PLA-PEG, DGL-PEG, PTMC-PEG, and PDSGM-PEG, are known to help move drugs across the blood-brain barrier.

Hydrogel

Hydrogels are made of polymer networks that are either physically or chemically linked. They have the ability to absorb water and interact with some organic solvents. The hydrogel-based nanodrug delivery system is very safe for the body, breaks down easily, and is not harmful. It helps in releasing medicine slowly and targeting specific areas. In cancer treatment, the body's immune response to radiation therapy is often not strong enough. Therefore, immune adjuvants are used to help the body's immune cells work better. Wang and their team created a nanomotor made of h

hydrogel that responds to nearinfrared light. This nanomotor can go through tumor tissue and release medicine inside the cells, which helps the body's immune system work more effectively. It combines three treatments: light therapy, chemotherapy, and immunotherapy, leading to better results.

Soft hydrogels are great for repairing different types of tissue damage. Li and their team made a nanofiber hydrogel that doesn't swell much. It is safe for the body and breaks down easily. It helps cells move and speeds up the formation of new blood vessels during the healing of wounds. Sun and their team developed a new hydrogel system that carries special molecules. These molecules can bind to ATP released by cancer cells when they are treated with oxaliplatin or X-ray radiation. This helps release immune boosters, making the treatment more effective.

In the field of veterinary medicine, Gao and their team made a gel vaccine that changes shape with temperature. It is safe, breaks down, and releases the vaccine slowly. A vaccine made with this gel and a special DNA plasmid has been shown to strongly activate the body's immune system, both in terms of antibodies and T cells. It helps the body fight viruses better and keeps the immune protection going longer. Recently, the Shanghai Veterinary Research Institute of the Chinese Academy of Agricultural Sciences developed a new type of hydrogel called Hydrogel RL that includes antimicrobial peptides. Lab tests show that this hydrogel releases its contents over time, is safe for the body, and is very effective against a type of bacteria called MRSA that is resistant to many antibiotics.

Metal and inorganic nanoparticles

Metal and inorganic nanoparticles are a key part of nanomedicine delivery systems. These tiny particles are made from metals or inorganic materials through special methods like physical or chemical processes. They have special features such as a large surface area, good ability to enter the body, low harmful effects, and the ability to mix well with many liquid chemicals. Because of these qualities, they are useful in treating cancer in combination with other treatments. Examples include nanographene oxide, carbon nanotubes, mesoporous silica, calcium-based nanoparticles, magnetic nanoparticles, copper nanoparticles, and gold nanoparticles. These materials are helping to move the field of nanomedicine forward.

Zhao and their team used copper ions along with other things in a way that increases stress in the body, which helps make immunotherapy more effective when combined with chemotherapy. This method has changed the environment around a tumor so that it's less able to stop the immune system from working. It has made immunotherapy more successful and reduced the growth of tumors. Their research gives new ideas of how to develop better treatment methods to stop cancer from

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spreading.

Gong an their team created a special type of carbon quantum dot that is filled with phosphorus and nitrogen. This carrier helps carry a drug called DOX better into the nucleus of cancer cells and gathers more in the tumor. This leads to a better effect in stopping tumor growth. Another important material is a multifunctional CuS nanocomposite that is used to carry both oligonucleotides and a drug called docetaxel. When used together with light-based treatments like photothermal and photodynamic therapy, this helps Tc cells move into the tumor area and increases the effectiveness of breast cancer treatment.

Micro Infusion Implantation Device

Intracranial drug delivery has been found to lower the risk of drug tolerance by linking an implanted catheter to a subcutaneous drug reservoir or an external microinfusion pump. This pump releases medicine in short, programmed bursts. This method is mainly used to treat conditions like epilepsy and severe pain. A recent clinical study used a subcutaneous microinfusion pump connected to a catheter system to deliver broad-spectrum valproic acid directly into the ventricles of patients with drug-resistant epilepsy. The results showed improvement in the patients' quality of life, and there was no toxicity around the ventricles, though some mild side effects were noticed. Similarly, intrathecal drug infusion delivers medicine directly into the space around the spinal cord, allowing the drugs to act on the spinal center for long-term pain management. This method works well, with a much smaller dose compared to intravenous or oral medication—just 1/1000 of intravenous and 1/300 of oral doses—which reduces long-term side effects. Once implanted, the procedure is simple and easy, which greatly improves the patient's quality of life. An innovative injectable capsule, called LSOMA, has been developed. It has an advanced mechanism for delivering drugs. This system can hold both small and large molecules, like monoclonal antibodies, and doubles the amount of medicine it can carry. LSOMA can reach a plasma concentration similar to subcutaneous injections within 30 minutes after use and can achieve a high bioavailability of 80% within a few hours.

Advantages of novel drug delivery system:

1. Protection from physical and chemical degradation.
2. Sustained delivery.

3. Improved tissue macrophages distribution.
4. Enhancement of stability.
5. Enhancement of pharmacological activity.
6. Protection from toxicity.
7. Increased bioavailability.
8. Enhancement of solubility.

Applications of NDSS

There are many possible uses for new drug delivery methods in the pharmaceutical and medical fields. These systems help patients take their medicine more easily, make treatments work better, and reduce unwanted side effects. Here are some important uses of new drug delivery systems.

Targeted Drug Delivery: One main use of new drug delivery systems is delivering medicine directly to the part of the body that needs it, like a tumor or a certain organ. This helps treat the problem in one area, lowers the amount of medicine in the rest of the body, and reduces side effects.

Controlled Release: New drug delivery systems can slowly release medicine over time. This keeps the right amount of medicine in the body for longer, making treatment more effective. It also means patients don't have to take their medicine as often, which helps them follow their treatment plan better.

Personalized Medicine: These systems can be made to suit each patient's needs. This allows for personalized medicine, where the treatment is tailored to work best for that person, making the medicine more effective and causing fewer side effects.

Chronic Disease Management: Many new drug delivery systems are used for long-term illnesses. These systems provide medicine that works over a longer time, reducing how often patients need to take it. This makes it easier for patients to stick with their treatment.

Combination Therapies: New drug delivery systems can send more than one medicine at the same time or one after another. This helps with combination therapies, where different medicines work together to improve treatment results. This is especially useful for treating serious illnesses or infections that are hard to treat.

Gene and Cell Therapies: Drug delivery systems are important in gene and cell therapy. They help send genetic material or special cells to the right place in the body, allowing for more effective and targeted treatment. These systems also help protect the genetic material or cells from being broken down and make it easier for the body to use them.

Vaccines: New drug delivery systems can also help in making and giving vaccines. They can make vaccines more stable and effective, help the body recognize harmful germs better, and slowly release vaccine parts over time, leading to a stronger immune response and better protection against diseases.

SUMMARY :-

Over the last 20 years, drug delivery systems have changed a lot. They have moved from large scale methods to smaller, more precise nanoscale technologies and are now moving towards smart, targeted ways to deliver drugs. This paper gives a detailed look at the latest developments in drug delivery systems. Nanoscale systems are very flexible because they can use a wide range of materials, like organic, inorganic, and mixed types. These systems use the special features of nanoparticles, such as their tiny size, how they behave in small spaces, their surface properties, and quantum effects. These features help improve drug solubility, stability, and the ability to reach specific targets. Because of this, they show a lot of promise for use in medicine. However, there are still some problems that need to be solved. The way nanocarriers interact with cell membranes and the tissue around cells needs more research. Also, the harmful effects these systems might have on cells and the immune system need to be studied carefully, especially in animal tests. Biological carriers, made from natural substances that keep the structure and function of their original sources, could help reduce unwanted immune responses. These carriers can mimic the structures or actions of infectious agents, allowing them to deliver drugs exactly where they are needed. This makes them a very promising option for targeted drug delivery. Some experts believe that combining drug delivery systems with advanced technologies like microfluidics, 3D printing, CRISPR-Cas9, and quantum sensing could be the future of drug delivery. But these ideas are still in the idea stage, and there are limits on FDA-approved drug delivery systems. Because of this, more research and clinical trials are needed to make these modern delivery systems more effective for real-world medical use. Using multiple drug delivery systems together is also a promising strategy, taking into account factors like how toxic the drugs are, possible side effects, how they are given, and the correct dose.

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