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Recent Advances in Novel Drug Delivery System: A Review

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ABSTRACT

The development of novel drug delivery systems (NDDS) for medications has received a lot of interest during the last few decades. Idealistically, the innovative carriers should meet two requirements. The medicine should first be delivered throughout treatment at a rate determined by the body's needs. Second, it should direct the herbal drug's active ingredient to the place of action. None of these can be satisfied by conventional dosage forms, including prolonged-release dosage forms. Bioactive and plant extracts have been used to create some innovative herbal formulations, including liposomes, Nanoparticles, Niosomes, microspheres, and Resealed erythrocytes. Drug products contain additional components that are likewise "functional" the drug product, in addition to the "actives" that impart the therapeutic benefits intended, such as pain alleviation or action on a specific portion of the body. These are referred to as excipients, and the specific functionality that they give a given product depends less on how they were added to the formulation than on where they were placed in the dosage form. This article covers the different NDDS and their recent advances.

INTRODUCTION:

To improve drug solubility, sustainability, bioavailability, and gastrointestinal permeability, a variety of strategies have been used. The creation of new pharmacological carriers and delivery systems has given nanocarriers a lot of attention[1]. Utilizing a biodegradable and biocompatible nanoparticle to encapsulate natural plant metabolites is one way to combat this issue. Tuning the physiochemical properties of nanocarriers is also thought to be largely influenced by changing their primary characteristics, such as their constituents (organic, inorganic, or hybrid), sizes (small, medium, or large), shapes (sphere, rod, or cube), and surface properties (charge, functional groups, PEGylation, or attachment of targeting moieties). The overall goal of using nanocarriers in drug delivery is to effectively treat a condition with the fewest possible side effects and outcomes[2].

The limitations of the conventional drug delivery methods are addressed by the innovative drug delivery system, which is a novel method of drug administration. Our nation possesses a wealth of Ayurvedic knowledge, but only recently has its full potential been recognized. However, the traditional and antiquated drug delivery method used to give the patient herbal medicine causes a reduction in the drug's effectiveness[3]. If cutting-edge drug delivery technology is used in herbal medicine, it could improve the effectiveness and lessen the negative effects of different herbs and herbal compounds. This is the fundamental idea behind the use of novel drug delivery systems in herbal medicines[4].

The foundation of medicine lies in the past before chemists set out to create artificial cures for every ailment and pharmaceutical companies tethered our collective well-being to what has since grown to be a multibillion-dollar business. Nearly all medications in the past came from plants, which for a long time served as man's sole source of chemistry. Herbal "renaissances" are taking place all over the world, and more and more people are turning to herbal therapies in place of conventional medicine to treat a variety of ailments. The way a medicine is administered can significantly affect how effective it is[5]. Some medications have an ideal concentration range within which the greatest benefit is obtained; concentrations outside of this range can be hazardous or fail to have any therapeutic benefit. The very slow improvement in the effectiveness of treating severe diseases, on the other hand, has indicated a growing need for a multidisciplinary approach to the delivery of therapeutics to targets in tissues. This led to the development of fresh concepts for regulating the pharmacokinetics, pharmacodynamics, non-specific toxicity, immunogenicity, biorecognition, and efficacy of

medications. These novel approaches frequently referred to as drug delivery systems (DDS), are based on interdisciplinary methodologies that integrate polymer science[6].

To reduce drug loss and degradation, avoid negative side effects, increase drug bioavailability, and increase the fraction of the drug accumulated in the desired zone, a variety of drug delivery and drug targeting systems are currently being developed. Soluble polymers, microparticles made of insoluble or biodegradable natural and synthetic polymers, cells, cell ghosts, lipoproteins, liposomes, and micelles are examples of drug carriers. The carriers can be made to slowly degrade, react to stimuli (such as changes in temperature or pH), and even be targeted[7].

➢ **Types of Nanocarrier**

✓ **Nanostructured Lipid Carrier (NLC)**

It is regarded as a second-generation lipid nanoparticle that was derived from SLN but has more flaws in the lipid matrix. It has a mixture of solid and liquid lipids. 22 There have been many different types of solid lipids used, including hydrogenated palm oil (HPO), glyceryl monostearate, stearic acid, and cetyl alcohol, while olive oil, mustard oil, castor oil, and cod liver oil are the most frequently used liquid lipids. Thimerosal is the preferred stabilizer in this system. The successful synthesis of 2Cardomom essential oil (CEO) loaded NLCs with food-grade lipids like cocoa butter and olive oil.The CEO-loaded NLCs have good physical and chemical stability, a compact size (90%), and a high loading capacity (>25%). The CEO's inability to be applied to aqueous-based foods was overcome by this work. 26 Currently, several novel and cutting-edge NLC have been developed as a carrier to target anticancer functions, including zerumbone, thymoquinone, and citral, and as a worthy drug observably increased antitumor activity in leukemia and breast tumour cells in vitro and in vivo[8].

✓ **Carrier-based Drug Delivery System:**

A) Liposomes

In the middle of the 1960s, the sphere-shaped vesicles known as liposomes, which contain one or more phospholipid bilayers, were first described. In today's research, they are a very useful reproduction, reagent, and tool in many fields, including math and theoretical physics, biophysics, chemistry, colloid science, biochemistry, and biology. Since that time, liposomes have entered the market. Liposomes are one of many innovative new drug delivery systems,

and several formulations are currently being used in clinical trials. They represent cutting-edge technology for delivering active molecules to the site of action. From conventional vesicles to "second-generation liposomes," which are long-circulating liposomes obtained by modulating the vesicle's lipid composition, size, and charge, liposome technology has advanced. Additionally, liposomes with altered surfaces have been created using a variety of molecules, including glycolipids[9].

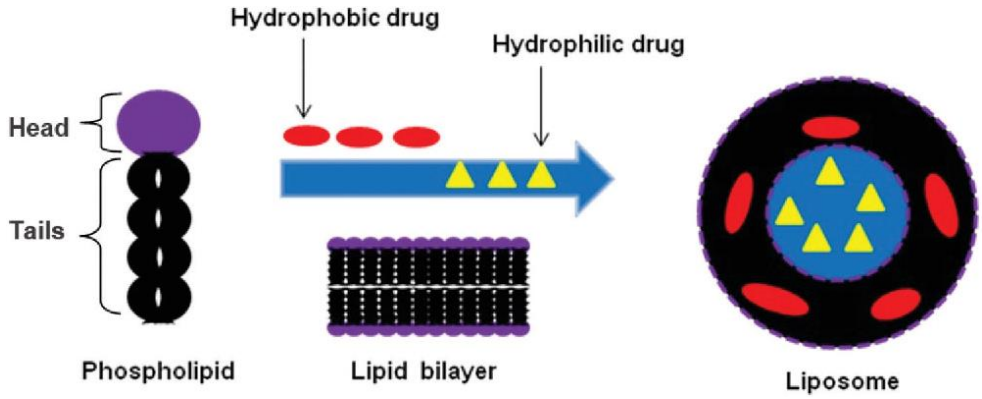

Fig 1: Liposomes

Recent advances

Over the past 30 years, liposomes, which are microscopic phospholipid bubbles with a bilayered membrane structure, have drawn a lot of attention as pharmaceutical carriers with enormous potential. Gene delivery and cancer therapy continue to be the two main areas of interest, but more recent years have seen a plethora of new developments in the field of liposomal drugs, ranging from clinically approved products to novel experimental applications. Promising trends must be found and taken advantage of for this field to continue to develop successfully, though with a clear understanding of the approaches' limitations[10].

B) Nanoparticles

Materials in the nanoscale range are used as diagnostic tools or to deliver therapeutic agents to specifically targeted sites in a controlled manner in nanomedicine and nano-delivery systems, which is a relatively new but rapidly developing science. By delivering precise medications to specific locations and targets, nanotechnology offers numerous advantages in the treatment of chronic human diseases. The use of nanomedicine (including chemotherapeutic agents, biological agents, immunotherapeutic agents, etc.) in the treatment of various diseases has recently seen some outstanding applications[11].

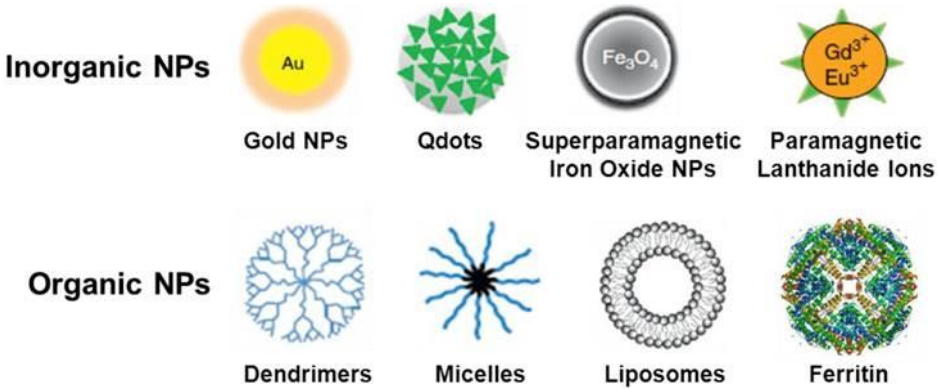

Fig 2: Types of Nanoparticles

Recent Advances

A significant class of nanomaterials known as gold nanoparticles (GNPs) is valued for their superior physicochemical features, which make them useful in medicinal applications. Recently, a new platform for the early detection and treatment of cancer has been expanded thanks to the special optical features of GNPs and their application in photothermal and radiation. GNP-based nanostructures have a wide surface area, are non-toxic, and are biocompatible. This allows for surface modification with many compounds, including various polymers, antibodies, and even medicinal molecules. As a result, they are used for targeted medication delivery to transport pharmaceuticals and deliver them selectively to the intended tissues, reducing their damaging effects on healthy cells while increasing the drug dose to malignant ones. This review mostly discusses GNPs' fundamental characteristics[12].

C) Microspheres

Multiparticulate drug delivery systems called microspheres are created to achieve prolonged or controlled drug delivery to increase bioavailability, and stability, and to target the drug to a specific site at a set rate. They are made of natural, semi-synthetic, and synthetic polymers as well as other protective ingredients like polymeric wax. Microspheres are typically free-flowing powders made of proteins or synthetic polymers, with particle sizes ranging from 1-1000 m. The variety of methods for creating microspheres offers several ways to regulate aspects of drug administration and improve the therapeutic potency of a particular drug[13].

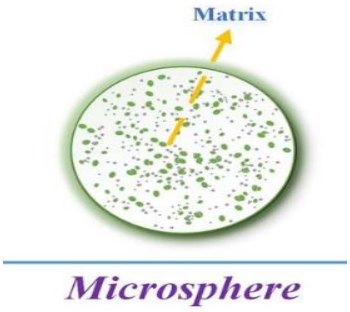

Fig 3: Microsphere

Recent advances

Microspheres have been subjected to in vitro release testing using sample and separate, dialysis membrane sacs, and USP apparatus IV. These methods have been compared, and USP apparatus IV has emerged. In vitro release tests that accelerate the testing process have been developed for quality control needs. In vitro-in vivo correlations have been built using real-time and accelerated release data to lessen the necessity for in vivo performance evaluation. Studies on storage stability have been done to see how different environmental factors affect microsphere quality throughout a product's shelf life. Along with improvements in characterization techniques for other Physicochemical parameters such as particle size, drug content, and thermal properties, new tests such as the floating test and the in vitro wash-off test have been developed[14].

D) Monoclonal antibodies

Monoclonal antibodies (MAbs) have seen a remarkable transition during the past three decades, going from being useful research tools to potent human medicines. The first therapeutic MAb authorized by the FDA for the prevention of kidney transplant rejection was muromonab CD3, a murine MAb. From the time of its approval in 1986 until the late 1990s, when the first chimeric Mab, rituximab, was authorized for the treatment of low-grade B cell lymphoma, there was a decline in subsequent applications and approvals. The rate of approval and the number of monoclonal antibodies available on the market for the treatment of various diseases has dramatically increased since chimeric, then humanized, and finally fully human monoclonal antibodies were given the green light by licensing authorities. About 60 therapeutic MAbs were approved by the FDA as of March 2017[15].

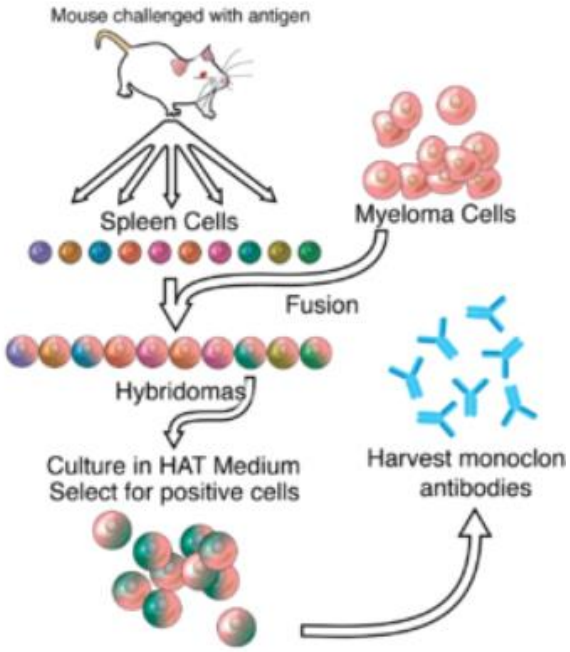

Fig 4: Monoclonal antibodies

Recent advances

The US FDA had approved 79 therapeutic mAbs as of December 2019, but there is still a lot of room for expansion. This review outlines the leading antibody engineering technologies, including affinity maturation, humanization of monoclonal antibodies, phage display, the human antibody mouse, and single B cell antibody technology, as well as the most recent market trends[16].

E) Niosomes

The management of infectious diseases and immunization practices have experienced a revolutionary change in recent years. With the development of biotechnology and genetic engineering, not only have numerous biologicals targeted at certain diseases been created but the focus has also been placed on the efficient delivery of these biologicals. As an alternative to liposomes, niosomes are vesicles made of non-ionic surfactants that are biodegradable, more harmless, more stable, and less expensive. This article examines the present growth and enlargement of interest in niosomes throughout a variety of scientific fields, with a focus on their use in medicine. Additionally, this article gives a general overview of niosome preparation methods, niosome types, niosome characterization, and niosome applications[17].

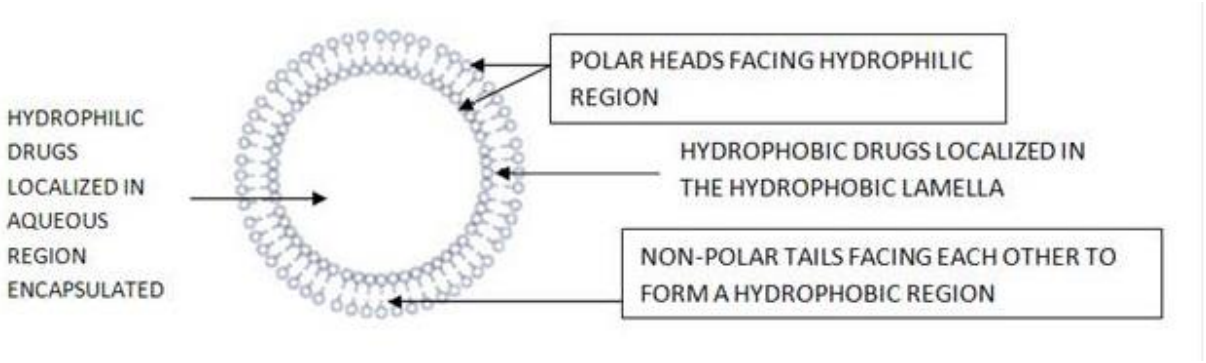

Fig 5: Niosomes

Recent advances

Due to its potential for targeted drug delivery to the sick region, while sparing the surrounding healthy tissue, the development of nanocarriers for drug delivery has drawn a lot of attention. The safe and effective distribution of medications has always been a problem in medicine. Making surfactant-based vesicles has garnered a lot of attention recently to enhance drug delivery. Niosomes, a versatile drug delivery system with uses ranging from dermal delivery to brain-targeted delivery, are self-assembled vesicular nano-carriers created by hydration of non-ionic surfactant, cholesterol, or other amphiphilic molecules. Numerous research articles detailing their fabrication processes and uses in the pharmaceutical and cosmetic industries have been published. Similar benefits to liposomes exist for niosomes, such as the capacity to combine hydrophilic and lipophilic substances. Additionally, niosomes have the advantages over liposomes in that they can be produced using straightforward techniques, at a lower cost, and with longer-lasting stability[18].

F) Resealed erythrocytes as drug carriers

Resealed erythrocytes can be loaded with a range of active medicinal compounds and are biocompatible, biodegradable, have a long circulation half-life, and are biocompatible. Re-sealed erythrocytes are preferable to other drug delivery methods because they have several benefits over them. By taking a blood sample from the target organism and separating the erythrocytes from the plasma, carrier erythrocytes are created[19]. The cells are split using a variety of techniques, the drug is then trapped inside the erythrocytes, and then the carriers are resealed and given the name "resealed erythrocytes." Re-sealed erythrocytes have excellent potential as a drug delivery system to improve therapeutic index and patient compliance. It has the potential to deliver medications to specific locations with the least

amount of medication waste while also delaying the onset of the medication. The side effects of numerous medications, including aspirin, steroids, and cancer treatments, are reduced by resealing erythrocytes. The current review highlights several resealed erythrocyte characteristics, drug-loading techniques, and applications[20].

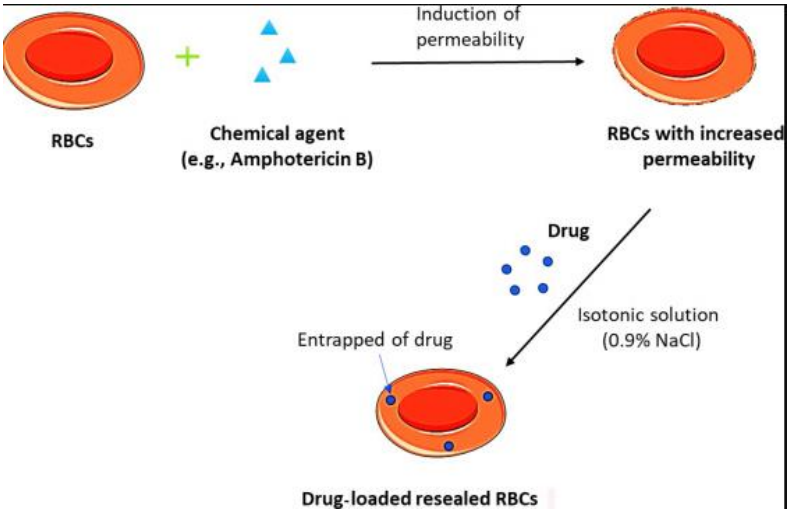

Fig 6: Resealed erythrocytes

Recent advances

To use the potential of erythrocytes in the passive as well as active targeting of medications in diseases like cancer, a significant amount of worthwhile effort is required. Given their enormous potential, erythrocytes now serve as the most efficient carriers in innovative drug delivery systems. A newer dimension can be added to the current cellular drug carrier concept by combining genetic engineering elements. We can transplant hormones and steroids to the targeted site using RBCs while minimizing their side effects. "Golden eggs in novel drug delivery systems" are erythrocytes[21].

CONCLUSION:

The term "novel drug delivery system" refers to methods, formulation technologies, and systems for delivering pharmaceutical compounds into the body as required to achieve their desired therapeutic effect while maintaining patient safety. The use of NDDS may be the key development in resolving the issue of drug release at a specific location and rate. Modifying existing excipients is very simple, more cost-effective, and time-effective than creating new excipient entities and evaluating them. One of the most crucial requirements for further advancement in the design of novel drug delivery systems is the creation of excipients that

can perform multiple functions, such as improving drug bioavailability and stability and controlling the release of the drug by therapeutic needs.

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