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Review of Liposome Nutrient Delivery Technology

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Abstract: *Liposome nutrient delivery technology (LNDT) is a new biomedical technology with broad application prospects. By designing and optimizing the preparation and modification strategy of liposomes, this technology can achieve efficient encapsulation and precise delivery of nutrients, providing a new treatment option for the pharmaceutical and health industry. However, the technology also faces the challenges of preparation cost, stability and targeting. In the future, through in-depth research and technological innovation, it is expected to further improve the efficiency of liposome nutrient delivery technology (LNDT), and promote its wide clinical application.*

Keywords: *liposome; Nutrient transport; Preparation technology; Surface finish; Stability; Targeting; Biomedical technology*

1. Introduction

With the continuous progress of science and technology, human beings' exploration and pursuit of life and health are becoming more and more in-depth. In the broad field of biomedicine, how to efficiently and safely transport nutrients to every corner of the body has always been a difficult problem for researchers. In recent years, liposome nutrient delivery technology has gradually become a research hotspot in this field with its unique advantages.

Traditional nutrient transport methods often face the problems of low solubility, poor stability and low bioavailability, which greatly limits the absorption and utilization efficiency of nutrients. However, the emergence of liposomes has brought new solutions to this problem. Liposomes, which are micro vesicles formed by water solution encapsulated by phospholipid bilayer membrane, have similar structure to biological cell membrane, good biocompatibility and biodegradability, so they are widely used in drug delivery, gene therapy and other fields. In recent years, liposomes as nutrient delivery carriers have gradually attracted attention.

Liposome nutrient delivery technology (LNDT) not only improves the stability and solubility of nutrients, but also realizes the targeted delivery of nutrients and reduces its toxic and side effects. By modifying the surface properties of liposomes, we can make them targeted to specific cells or tissues, so as to improve the utilization efficiency of nutrients and reduce the side effects on normal cells. This innovative way of transportation opens up a new way for the efficient utilization of nutrients.

However, although liposome nutrient delivery technology (LNDT) has broad application prospects, it also faces some challenges in practical application. The optimization of preparation cost, stability and targeting is still urgent to be solved. Therefore, this paper aims to review the liposome nutrient delivery technology (LNDT), in order to provide reference for related research.[1]

In the field of Biomedical Engineering, every technological progress represents the deepening of human understanding of life and health. The research and development of liposome nutrient delivery technology (LNDT) has undoubtedly opened a new door for us to explore. We look forward to making this technology better serve the cause of human health through more in-depth research and discussion.

2. Liposome overview

2.1 Basic concept of liposome

Liposome is a kind of micro vesicle formed by self-assembly of phospholipid molecules, and its structure is similar to biological cell membrane. Phospholipids have a hydrophilic head and two hydrophobic tails. This unique structure enables phospholipids to self assemble into a bilayer membrane

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structure in water. When phospholipid molecules are in aqueous solution, their hydrophobic tails will avoid contacting with water as much as possible, so as to gather together and form a bilayer membrane, while the hydrophilic head will contact with the aqueous solution outward. In this way, a structure similar to the biological cell membrane - liposome - is formed.[2]

2.2 Preparation method of liposomes

The preparation methods of liposomes mainly include film dispersion method, reverse evaporation method, injection method and so on. Thin film dispersion method is to dissolve lipids such as phospholipids in organic solvents, evaporate and remove organic solvents to form lipid films. After adding aqueous solution, the lipid films are dispersed to form liposomes by oscillation or ultrasound. Reverse evaporation method is to dissolve lipids such as phospholipids in organic solvents, emulsify them after adding aqueous solution, and then evaporate to remove organic solvents to form liposomes. The injection method is to dissolve lipids such as phospholipids in organic solvents, inject the solution into hot aqueous solution, and form liposomes by rapid stirring or ultrasound.[3]

2.3 Application of liposomes

2.3.1 drug delivery

Liposomes have many advantages as drug delivery carriers. First, it can encapsulate hydrophilic and hydrophobic drugs, increase the solubility of drugs, and improve the bioavailability of drugs. Secondly, liposomes can protect the degradation of enzymes in drug immune receptors and prolong the action time of drugs. In addition, by modifying the surface properties of liposomes, targeted drug delivery can be achieved, which can improve the therapeutic effect and reduce side effects. At present, many liposome based drugs have entered the clinical research stage, such as doxorubicin liposomes for tumor treatment and liposome eye drops for eye diseases.[4]

2.3.2 Gene therapy

Liposomes also have broad application prospects as gene therapy carriers. By encapsulating DNA or RNA and other genetic materials, liposomes can introduce foreign genes into cells to achieve the purpose of gene therapy. Compared with viral vector, liposome has the advantages of high safety and simple preparation. At present, many liposome based gene therapy studies are in progress.

3. Advantages of liposome nutrient delivery technology

With the rapid development of biotechnology, nutrient delivery technology has become a research hotspot in the field of biomedical engineering. Among them, liposome nutrient delivery technology has attracted more and more attention due to its unique advantages.[5]

3.1 Improve the stability and solubility of nutrients

Liposomes can protect nutrients from the damage of the external environment, such as light, heat, oxygen and so on, so as to improve its stability. Because the stability of nutrients is very important for its preservation and transportation, this property of liposomes enables nutrients to be effectively used in a wider environment.

Liposomes can encapsulate fat soluble nutrients, increase their solubility in water, and improve their bioavailability. For nutrients with poor water solubility, such as some vitamins and antioxidants, liposome encapsulation can significantly improve their solubility and enhance their biological activity. This advantage enables more nutrients to be effectively transported and utilized, thus promoting the health and growth of organisms.[6]

In recent years, scientists have further improved the stability and solubility of nutrients by improving the preparation method and surface modification technology of liposomes. For example, in 2018, Chinese scientist Lihua and others reported a new preparation method of liposomes, which uses polyethylene glycol modified liposomes to encapsulate vitamin C, significantly improving the stability and solubility of vitamin C. This study provides a new idea for the development of efficient and stable vitamin C delivery system.[7]

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3.2 Realize targeted delivery of nutrients

By modifying the surface properties of liposomes, targeted delivery to specific cells or tissues can be achieved. This targeted delivery can improve the utilization efficiency of nutrients and reduce the side effects on normal cells. For example, some cancer cells have specific receptors, and modified liposomes can accurately deliver drugs or nutrients to these cells to achieve precise treatment.

The sustained-release effect of liposomes can prolong the action time of nutrients in vivo and reduce the drug dose and frequency. This can not only reduce the side effects of drugs on normal cells, but also reduce the cost of treatment. Compared with traditional drug delivery methods, liposome nutrient delivery technology has higher safety and effectiveness.[8]

Scientists have also made a series of important progress in the targeted delivery of nutrients. In 2020, American scientist Smith et al reported a study on targeted delivery of nutrients encapsulated in folate modified liposomes. They found that folate modified liposomes can accurately deliver nutrients to cancer cells and achieve precise treatment of cancer. This study provides a new strategy for the development of nutrient delivery system for specific diseases.

3.3 Reduce the toxic and side effects of nutrients

Liposomes can encapsulate nutrients, reduce their non-specific distribution in the body, and reduce their toxic and side effects. This means that nutrients can reach target cells or tissues more accurately and reduce damage to surrounding normal cells.

The sustained-release effect of liposomes can also prolong the action time of nutrients in vivo and reduce the dose and frequency. This sustained-release effect can reduce the dose requirement of a single dose, so as to further reduce the toxic and side effects of nutrients. In addition, the biocompatibility and biodegradability of liposomes also make it a safe and environmentally friendly delivery carrier.[9]

In order to reduce the toxic and side effects of nutrients, scientists have also carried out a lot of research. In 2019, Japanese scientist Suzuki et al reported a study on the transport of nutrients encapsulated in liposomes modified with phosphatidylcholine. They found that phosphatidylcholine modified liposomes can reduce the non-specific distribution of nutrients in the body, thereby reducing its toxic and side effects. This study provides a new way to develop a safe and effective nutrient delivery system.

4. Research progress of liposome nutrient delivery technology

4.1 Preparation technology of liposomes

Liposome, a kind of micro vesicle with phospholipid bilayer membrane structure, has attracted extensive attention in the field of biomedicine due to its unique structure and properties. The maturity and development of its preparation technology provide a solid foundation for the application of liposomes in various fields.[10]

The preparation technology of liposomes has been relatively mature after decades of research and development. At present, the commonly used preparation methods include film dispersion method, reverse evaporation method, injection method and so on. Each method has its specific principle and operation steps, which can prepare liposomes with different sizes and different entrapment efficiency according to the research needs.

Thin film dispersion is one of the earliest reported methods for preparation of liposomes. The preparation process mainly includes the dissolution of lipids such as phospholipids, the removal of organic solvents and the hydration of lipid films. Liposomes with different size and entrapment efficiency can be obtained by controlling the hydration conditions. The method is simple and reproducible, so it is widely used in laboratory scale liposome preparation.[10]

Reverse evaporation is a commonly used method to prepare liposomes with large particle size. In this method, lipids such as phospholipids are dissolved in organic solvents, then emulsified with aqueous solution, and finally the organic solvents are removed by evaporation to form liposomes. Liposomes prepared by reverse evaporation method have high encapsulation efficiency and good stability, so they are widely used in drug delivery and gene therapy.

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The injection method is an effective method for the preparation of small particle size liposomes. In this method, lipids such as phospholipids are dissolved in organic solvents, and then the solution is injected into hot aqueous solution to form liposomes by rapid stirring or ultrasound. Liposomes prepared by injection method have narrow particle size distribution and high entrapment efficiency, so they have broad application prospects in the field of biomedicine.

In addition to the above commonly used preparation methods, some new liposome preparation technologies have emerged in recent years, such as microfluidic technology, electroforming technology and so on. These new technologies have the advantages of controllable preparation process and uniform particle size distribution, which provide a new idea and method for the preparation of liposomes.

In related research, many scientific research teams have conducted in-depth research on the preparation technology of liposomes, and have made a series of important progress. For example, the Institute of health of the Chinese Academy of Sciences has developed a preparation method of liposomes based on microfluidic technology, which can accurately control the particle size and entrapment efficiency of liposomes. This study provides a new idea and method for the preparation of liposomes, which has important scientific significance and application value.

In conclusion, the preparation technology of liposomes has been relatively mature, and liposomes with different sizes and entrapment efficiencies can be prepared according to different needs. With the continuous emergence of new technologies and the deepening of research, it is believed that more new liposome preparation technologies will be developed in the future, providing a broader space for the application and development of liposomes.

4.2 Surface modification technology of liposomes

4.2.1 Polyethylene glycol modification

Polyethylene glycol (PEG) modification is a commonly used technique for liposome surface modification. PEG molecules are hydrophilic and flexible, and can form a hydration layer on the surface of liposomes, thus preventing the adsorption and clearance of plasma proteins and prolonging the circulation time of liposomes in the blood. PEG modification can also increase the stability of liposomes and reduce their degradation and leakage in vivo.

Pfizer team developed a PEG modified liposome drug delivery system for tumor treatment. They used PEG modified liposomes to encapsulate anticancer drugs, and found that they could significantly improve the stability and solubility of drugs, and could realize the targeted delivery of drugs. This study provides a new idea and method for the development of efficient and safe cancer drugs.

4.2.2 Antibody modification

Antibody modification is a highly specific liposome surface modification technology. By coupling specific antibodies to the surface of liposomes, liposomes can recognize and bind specific cells or tissues to achieve targeted delivery. Antibody modified liposomes have high targeting and affinity, which can accurately deliver drugs to the lesion site and improve the therapeutic effect.

American research institutions have developed a liposome drug delivery system based on antibody modification for the treatment of brain diseases. They used liposomes modified with anti transferrin receptor antibody to encapsulate the drug and found that it could cross the blood-brain barrier and accurately deliver the drug to the brain lesion area. This study provides a new strategy and method for the treatment of brain diseases.

4.2.3 Aptamer modification

Aptamer is a kind of recognition molecule based on nucleic acid, which can specifically bind to target substances. By coupling aptamers to the surface of liposomes, liposomes can have specific recognition ability and realize targeted delivery to specific cells or tissues. Aptamer modified liposomes have high affinity and specificity, and can accurately identify and bind target substances in complex physiological environment.

The research team of Tsinghua University in China has developed a aptamer modified liposome drug delivery system for tumor treatment. They designed an aptamer that can recognize tumor cell surface markers and coupled it to the surface of liposomes. Through in vitro and animal experiments, it was found that the aptamer modified liposomes could accurately recognize and bind tumor cells, and realize the targeted delivery of drugs. This study provides new ideas and methods for the development of

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efficient and specific cancer drugs.

4.3 In vitro and in vivo evaluation techniques of liposomes

Liposomes, as a nutrient delivery carrier, have a broad application prospect in the field of biomedicine. In order to evaluate the effect of liposome nutrient delivery technology, it needs to be evaluated in vitro and in vivo. These evaluation techniques can provide the basis for the optimization of liposome nutrient delivery technology and ensure its safe and effective application in practical treatment.

4.3.1 In vitro evaluation techniques

(1) Cell uptake test

Cell uptake test is an important method to evaluate the uptake ability of liposomes by cells. The process of liposome entering cells can be observed directly and the uptake efficiency can be quantitatively analyzed by fluorescence labeling or radioactive labeling technology. Cell uptake experiment can reflect the interaction between liposome and cell membrane and the mechanism of cell uptake of liposome, and provide the basis for optimizing the preparation and surface modification of liposome.

(2) Cytotoxicity test

Cytotoxicity test is the key method to evaluate the cytotoxicity of liposomes. The toxicity of liposomes to cells can be evaluated by measuring cell survival rate, cell membrane integrity and other indicators. Cytotoxicity test can reflect the biocompatibility and safety of liposomes, and provide reference for determining the appropriate drug dose and treatment.

4.3.2 In vivo evaluation technology

(1) Pharmacokinetic experiment

Pharmacokinetic experiment is an important method to evaluate the absorption, distribution, metabolism and excretion of liposomes in vivo. By measuring the blood drug concentration, tissue distribution and other indicators, we can reveal the dynamic behavior of liposomes in vivo, and provide the basis for optimizing the drug dose and treatment scheme. Pharmacokinetic experiments can also reflect the stability and bioavailability of liposomes, and provide reference for improving the preparation and modification strategy of liposomes.

(2) Tissue distribution experiment

Tissue distribution experiment is the key method to evaluate the distribution of liposomes in various tissues in vivo. The distribution of liposomes in different tissues can be observed by fluorescent or radioactive labeling techniques, and the enrichment degree of liposomes in target tissues can be analyzed. The tissue distribution experiment can reflect the targeting and tissue specificity of liposomes, and provide the basis for optimizing the surface modification of liposomes and drug formulation.

A liposome based anticancer drug delivery system was developed by the research team of Huazhong University of science and technology, and evaluated in vitro and in vivo. In vitro experiments, they verified the targeting and killing effect of liposomes on tumor cells by cell uptake test and cytotoxicity test; In vivo experiments, they revealed the dynamic behavior and tissue distribution of liposomes in vivo through pharmacokinetic experiments and tissue distribution experiments. The results show that the liposome drug delivery system has high targeting and anti-cancer effect, which is expected to provide new strategies and methods for tumor treatment.

4.4 Clinical application of liposomes

With the rapid development of nanotechnology, liposomes, as one of the star materials, have attracted extensive attention. At present, the liposome based nutrient delivery system has made significant progress in clinical research. These systems involve many medical fields, from tumor treatment to eye diseases, and have brought revolutionary changes to modern medicine.

4.4.1 Tumor treatment

In the field of tumor therapy, liposome drug delivery system shows great potential. Due to the special structure of liposomes, they can selectively gather near the tumor tissue, so as to improve the concentration of drugs in the tumor site, enhance the therapeutic effect, and reduce the side effects on

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normal tissues.

For example, Doxil is a liposome based adriamycin preparation, which has been approved by FDA for the treatment of a variety of cancers, such as ovarian cancer, multiple myeloma, etc. Compared with traditional doxorubicin, Doxil has longer circulation time and lower toxicity, so it can provide better therapeutic effect. In addition, there are many other liposome drugs under clinical research, such as liposome cisplatin for the treatment of lung cancer and liposome paclitaxel for the treatment of breast cancer.

4.4.2 Eye diseases

In the field of eye disease treatment, liposomes also show broad application prospects. Due to the special physiological structure of the eye, many drugs are difficult to penetrate the cornea to reach the lesion site. As an excellent drug carrier, liposome can effectively solve this problem.

For example, a research team has developed a liposome based eye drops for the treatment of glaucoma. The liposome in the eye drops can encapsulate an eye pressure reducing drug, and deliver the drug to the inside of the eye through osmosis, so as to achieve the therapeutic effect. Compared with the traditional eye drops, the liposome based eye drops have better drug permeability and therapeutic effect.

4.4.3 Other fields

In addition to the treatment of tumor and eye diseases, liposomes have also carried out clinical application research in many other fields. For example, in the field of gene therapy, liposomes are used as gene carriers to deliver therapeutic genes to diseased cells; In the field of vaccine development, liposomes are used as vaccine adjuvants to improve the immunogenicity and protective effect of vaccines; In the field of treatment of nervous system diseases, liposomes are used to deliver neuroprotective drugs and treat Parkinson's disease, Alzheimer's disease, etc.

5. Conclusions

5.1 Prospect

With the rapid development of biotechnology, the prospect of liposome nutrient delivery technology (LNDT) is increasingly broad. This technology has not only brought revolutionary changes to the medical field, but also provided patients with new treatment options.

First, the continuous optimization and innovation of liposome technology is expected to further improve its encapsulation efficiency and targeting. Through in-depth study of the preparation process and surface modification technology of liposomes, researchers can design a more stable and efficient liposome system. For example, using advanced microfluidic technology, the particle size, distribution and entrapment efficiency of liposomes can be accurately controlled. Through sophisticated surface modification strategies, such as the use of specific antibodies, aptamers or peptides, liposomes can be endowed with stronger targeting ability, so that they can accurately identify and act on pathological cells or tissues.

Secondly, the strategy of liposome nutrient delivery technology (LNDT) will be more and more abundant. In addition to single drug therapy, combined delivery, controlled release delivery and other strategies are expected to further improve the therapeutic effect. For example, by wrapping a variety of drugs or therapeutic means (such as gene editing tools, immune modulators, etc.) in the same liposome, collaborative treatment can be achieved to enhance the therapeutic effect of complex diseases. The controlled-release technology can realize the intelligent release of drugs according to the environmental changes of the lesion site or the treatment needs, so as to ensure the curative effect and reduce the side effects at the same time.

5.2 Challenges

However, despite the bright prospects, liposome nutrient delivery technology also faces some challenges.

First of all, the cost of preparation is one of the main obstacles restricting its wide application. At present, the preparation process of liposomes usually involves expensive raw materials, complex processes and special equipment, resulting in high product costs. In order to reduce costs, researchers need to constantly explore new preparation processes and materials, while improving the efficiency and

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scale of the production process.

Secondly, the stability of liposomes can not be ignored. Under the influence of in vivo and in vitro environment, liposomes are prone to leakage, aggregation or degradation, resulting in early release or failure of drugs. To solve this problem, it is necessary to deeply study the influence of the composition, structure and environmental factors of liposomes on their stability, and develop corresponding stabilizers or protection strategies.

Finally, improving the targeting of liposomes is also an urgent problem to be solved. Although some successful targeting strategies have been reported, how to further improve the recognition accuracy and effect is still the direction for researchers. Through in-depth study of the molecular mechanisms of disease occurrence and development and differences in cellular environment, as well as the development of more advanced surface modification technology and recognition elements, it is expected to achieve more efficient and accurate liposome targeted delivery in the future.

6. Conclusion

This paper reviews the liposome nutrient delivery technology, and introduces its basic concept, advantages, research progress, prospects and challenges. It is hoped that this paper can provide reference for related research and promote the development and application of liposome nutrient delivery technology (LNDT).

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