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Review Article

Brief Review on Niosome

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ABSTRACT

In recent years, there has been a groundbreaking transformation in the way infectious diseases are treated and immunizations are administered. Due to the progress in biotechnology and genetic engineering, a wide range of disease-specific biologicals has been created, with attention also given to their efficient delivery. Niosomes consist of non-ionic surfactants and are biodegradable, relatively safe, more stable, and cheaper, serving as a substitute for liposomes. This article explores the increasing interest in niosomes across various scientific fields, focusing on their medical applications specifically. This article also provides a summary of niosome preparation techniques, types of niosomes, characterization, and their uses. Niosomes, self-assembled non-ionic surfactant-based vesicles, have emerged as versatile drug delivery systems offering improved bioavailability, stability, and targeted delivery. By encapsulating bioactive molecules, niosomes enhance solubility, reduce toxicity, and provide controlled release. Applications encompass pharmaceuticals (cancer, infectious diseases), cosmetics (skin, hair), and biomedicine (diagnostic imaging, tissue engineering). Ongoing research focuses on optimizing formulations, surfactant chemistry, and scalability. Niosomes hold promise for revolutionizing drug delivery, improving therapeutic outcomes, and enhancing human health.

INTRODUCTION

This is capable of containing both hydrophilic and hydrophobic medications. These nanoparticles, referred to as vesicular delivery systems, work as Niosomes to enhance the therapeutic efficacy of drugs by altering their surface and limiting their effects to certain cells, which lowers the drug's clearance. Because of their distinct benefits, vesicular nanocarriers called Niosomes have drawn a lot of interest as possible drug delivery methods during the past 30 years. Their amphiphiles molecules are arranged in lamellar (bilayer) structures, which are encircled by an aqueous compartment. [1]Nonionic surfactants, which are composed of sugar-, polyoxyethylene-, polyglycerol-, and crown ether-based surfactants,

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can be employed as possible drug delivery systems. Membrane additives, such as cholesterol or its derivatives, are occasionally combined with nonionic surfactants to form Niosomes bilayer membrane[2] Many types of research have been conducted on the use of niosomes as drug carriers, and in various studies, it has been observed that niosomes as a carrier play an important role in the treatment of fungal diseases, wound healing, rheumatoid arthritis (RA), psoriasis, and other inflammation-related disorders (Marianecci et al., 2012; Osanloo et al., 2018; Farmoudeh et al., 2020; Qiu et al., 2021; Raja et al., 2022). In addition, Manosri et al.,suggested that niosomes can be used as carriers for gene delivery through the skin. Contextually, the transactivator of transcription (TAT, GRKKRRQRRRPQ) peptide has been evaluated in transdermal drug delivery using niosomes on mouse skin. In this study, transdermal absorption and stability of tyrosinase plasmid increased (Manosroi et al., 2013). In another study, pergolide, an antiParkinson disease therapy, was examined for its penetration through human skin. It was found that the penetration dependent on the pH of the carrier, and the pH of niosomal formulation can be a determining factor for transdermal drug delivery (Ge et al., 2019). Due to the physicochemical properties of niosomes, they can load a large number of medicines and increase the bioavailability of drugs by passing through different body barriers, such as the skin and gastrointestinal (GI) barriers (FDA, 2023).[3] Niosomes are non-ionic surfactant-based vesicles that have gained significant attention as a novel drug delivery system. These vesicular structures, composed of non-ionic surfactants, cholesterol, and other lipids, offer improved stability, biocompatibility, and versatility compared to traditional liposomes [4,5]. Niosomes were first introduced in the 1970s by Handjani-Vila et al. as an alternative to liposomes (6]The unique properties of niosomes, including their ability to encapsulate both hydrophilic and lipophilic drugs, make them suitable for delivering a wide range of therapeutic agents Niosomes have shown potential in enhancing drug bioavailability, reducing toxicity, and improving therapeutic efficacy [7].

Structure and composition of noisome

Niosomes are hydrated vesicular systems of nonionic surfactants with phospholipid or cholesterol and deliver drugs to target sites. The lamellar structures of these vesicular systems are fabricated of amphiphilic molecules and surrounded by an aqueous compartment.

Bilayer Structure

1. Outer leaflet: Non-ionic surfactant molecules (e.g., Span 60, Tween 60) with hydrophilic heads facing outward [8]
2. Inner leaflet: Hydrophobic tails of surfactant molecules facing inward [9]
3. Hydrophilic core: Aqueous compartment entrapping hydrophilic drugs or molecules [10]

Fig no 1

Component of noisome

Non-ionic surfactant bilayer: The core component of a niosome, formed by non-ionic surfactants (e.g., polyglyceryl ethers, sorbitan esters).

2. Membrane stabilizers: Cholesterol, cholesteryl hemisuccinate, or dicetyl phosphate, which enhance stability and rigidity.

3. Aqueous core: The inner compartment, containing the encapsulated material (drug, vaccine, gene therapy agent).

Main Components

1. Non-ionic Surfactants: Main components of niosome membranes (e.g., Span 60, Tween 60)

2. Cholesterol: Adds stability and rigidity to the bilayer

3. Other Lipids: Phospholipids, glycolipids, and ceramides can be incorporated

Non-ionic Surfactants

1. Polyoxyethylene Alkyl Ethers (e.g., Tween 60)

2. Polyoxyethylene Alkyl Esters (e.g., Span 60)

3. Sorbitan Esters (e.g., Span 20)

4. Polysorbates (e.g., Tween 20)

Other Components

1. Phospholipids: Enhance membrane stability and fluidity

2. Glycolipids: Improve membrane interactions and targeting

3. Ceramides: Modulate membrane properties and permeability

4. Aqueous Core: Entraps hydrophilic drugs or molecules

Optional Components

1. Targeting Ligands: Enhance specificity and cellular uptake

2. Pegylation: Improves stability and reduces immunogenicity

3. Charged Lipids: Modulate membrane surface charge [11,12]

Methods of Preparation

1. Thin-Film Hydration Method: Most common method, involves dissolving surfactants and cholesterol in organic solvent, evaporating solvent, and hydrating film with aqueous solution

2. Reverse-Phase Evaporation Method: Involves dissolving surfactants and cholesterol in organic solvent, adding aqueous solution, and evaporating solvent

3. Extrusion Method: Involves passing surfactant mixture through porous membrane to form niosomes

4. Sonication Method: Involves using ultrasonic waves to disrupt surfactant mixture and form niosomes

5. Microfluidization Method: Involves using microfluidic device to mix surfactant mixture and aqueous solution

6. Dehydration-Rehydration Method: Involves dehydrating surfactant mixture, rehydrating with aqueous solution, and forming niosomes

7. Ether Injection Method: Involves injecting surfactant mixture into aqueous solution

8. Bubble Method: Involves generating bubbles in surfactant mixture to form niosomes [13,14]

Characterization Techniques

A] physical Characterization

1. Transmission Electron Microscopy (TEM): Visualizes niosome morphology and size.

2. Scanning Electron Microscopy (SEM): Analyzes niosome surface morphology.

3. Dynamic Light Scattering (DLS): Measures niosome size and size distribution.

4. Zeta Potential Measurement: Assesses niosome surface charge.

B] Chemical Characterization

1. Fourier Transform Infrared Spectroscopy (FTIR): Analyzes niosome composition and chemical interactions.

2. Nuclear Magnetic Resonance (NMR) Spectroscopy: Characterizes niosome structure and composition.

3. Mass Spectrometry (MS): Identifies niosome components and impurities.

C] Thermal Characterization

1. Differential Scanning Calorimetry (DSC): Analyzes niosome thermal properties and stability.
2. Thermogravimetric Analysis (TGA): Measures niosome weight loss and thermal stability.

Encapsulation Efficiency and Drug Loading

1. High-Performance Liquid Chromatography (HPLC): Quantifies drug encapsulation efficiency.
2. UV-Vis Spectroscopy: Measures drug concentration and encapsulation efficiency.

Stability and Release Studies

1. In vitro Release Studies: Evaluates niosome drug release profiles.
2. Stability Studies: Assesses niosome physical and chemical stability over time.

D] Biological Characterization

1. Cell Culture Studies: Evaluates niosome cytotoxicity and cellular uptake.
2. In vivo Studies: Assesses niosome biodistribution, pharmacokinetics, and efficacy.[15,16]

Application

A] Cosmetics and Personal Care

1. Skin moisturizing and hydration
2. Anti-aging and wrinkle reduction
3. Hair care and conditioning
4. Sunscreen and UV protection

B] Pharmaceutical Applications

1. Cancer therapy: Targeted delivery of anticancer drugs.
2. Gene delivery: Efficient delivery of genetic materials.
3. Vaccine delivery: Immunization and vaccine development.
4. Antimicrobial therapy: Targeted delivery of antimicrobial agents.

C] Biomedical Applications

1. Diagnostic imaging: Contrast agents for MRI and CT scans.
2. Tissue engineering: Scaffolds for tissue regeneration.
3. Wound healing: Topical delivery of growth factors.

D] Other Applications

1. Food industry: Encapsulation of bioactive compounds.
2. Agriculture: Pesticide and fertilizer delivery.
3. Veterinary medicine: Vaccine and drug delivery.

E] Drug Delivery Systems

1. Topical and transdermal delivery: Skin care, hair care, and sunscreen products.
2. Oral delivery: Gastrointestinal tract targeting.
3. Parenteral delivery: Injectable formulations.
4. Ophthalmic delivery: Eye drops and contact lenses. [17,18]

Advantages of Niosomes

1. Improved Bioavailability: Enhanced absorption and bioavailability of encapsulated drugs
2. Enhanced Stability: Protection of labile drugs from degradation and hydrolysis
3. Targeted Delivery: Site-specific delivery of drugs, reducing side effects
4. Biocompatibility: Non-toxic and biodegradable, reducing immune responses
5. Flexibility in Formulation: Can be formulated for various routes of administration
6. Increased Solubility: Enhanced solubility of poorly soluble drugs
7. Controlled Release: Sustained release of drugs, reducing dosing frequency
8. Improved Skin Permeability: Enhanced skin penetration and permeability
9. Reduced Systemic Toxicity: Minimized systemic side effects
10. Cost-Effective: Economical alternative to liposomes [19,20]

Limitations of Niosomes

1. Instability: Niosomes can be unstable and prone to aggregation or fusion
2. Low Entrapment Efficiency: Difficulty in encapsulating hydrophilic drugs
3. Short Shelf-Life: Limited storage stability due to surfactant degradation

4. Scalability Issues: Challenges in large-scale production
5. High Cost: Compared to traditional drug delivery systems
6. Limited Biological Data: Insufficient in vivo and clinical data
7. Toxicity Concerns: Potential toxicity of surfactants and other components
8. Immunogenicity: Potential immune responses to niosome components
9. Limited Control Over Release: Difficulty in controlling drug release rates
10. Regulatory Challenges: Limited regulatory guidance and standards [20,21].

Conclusion:

Niosomes are non-ionic surfactant-based vesicles that offer a promising drug delivery system with numerous advantages, including improved bioavailability, enhanced stability, targeted delivery, and biocompatibility. They have applications in pharmaceuticals, cosmetics, and biomedical fields. Niosomes are a promising vesicular drug delivery system offering improved bioavailability, stability, and targeted delivery. Their flexibility, biocompatibility, and cost-effectiveness make them an attractive alternative to traditional drug delivery systems.

CONCLUSION

Recent progress in scientific research has led to the recognition of proteins and vaccines as an important category of therapeutic substances. However, they present various issues related to drugs, including low bioavailability, appropriate drug delivery method, instability in physical and chemical properties, and potential adverse effects. Views on the efficacy of niosomes for delivering proteins and biological substances may lack evidence, but they have proven to be effective in encapsulating hazardous drugs like anti-AIDS, anti-cancer, and anti-viral medications. It offers a favorable delivery system when compared to ionic drug carriers that are toxic and not suitable. Nevertheless, the technology employed in niosomes is still in its early stages. Therefore, studies are being conducted to create an appropriate technology for mass production as it shows potential as a targeted drug delivery system.

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