World Journal of Pharmaceutical Science and Research
www.wjpsronline.com
Review Article
ISSN: 2583-6579
SJIF Impact Factor: 6.916
Year - 2026
Volume: 5; Issue: 2
Page: 652-669

A BRIEF REVIEW ON NIOSOMES AS A NOVEL DRUG DELIVERY SYSTEM

Jadhav Arati Prakash*[1], Kakde Swati B.[2], Dr. Jain S. R.[3], Prof. Tagad R. R.[4], Dr. Udapurkar P. P.[5]

[1,2]PG Scholar of Shri Sai College of Pharmacy Khandala Tq.Vaijapur Dist.Chh.Sambhajinagar Maharashtra, India-423701.
[3]Principal of Shri Sai College of Pharmacy Khandala Tq.Vaijapur Dist.Chh.Sambhajinagar Maharashtra, India – 423701.
[4]Assistant Professor of Shri Sai College of Pharmacy Khandala Tq.Vaijapur Dist.Chh.Sambhajinagar Maharashtra, India -423701.
[5]Professor of Shri Sai College of Pharmacy Khandala Tq.Vaijapur Dist.Chh.Sambhajinagar Maharashtra, India – 423701.

Article Received: 7 January 2026 | | ***Article Revised: 28 January 2026*** | | ***Article Accepted: 17 February 2026***

***Corresponding Author: Jadhav Arati Prakash**
PG Scholar of Shri Sai College of Pharmacy Khandala Tq.Vaijapur Dist.Chh.Sambhajinagar Maharashtra, India-423701.
DOI: https://doi.org/10.5281/zenodo.18712892

How to cite this Article: Jadhav Arati Prakash, Kakde Swati B., Dr. Jain S. R, Prof. Tagad R. R., Dr. Udapurkar P. P. (2026) A BRIEF REVIEW ON NIOSOMES AS A NOVEL DRUG DELIVERY SYSTEM. World Journal of Pharmaceutical Science and Research, 5(2), 652-669. https://doi.org/10.5281/zenodo.18712892

ABSTRACT

Drug delivery systems are designed to transport therapeutic agents effectively to their intended site of action in the body while minimizing systemic side effects and improving therapeutic outcomes. Conventional dosage forms often suffer from limitations such as poor bioavailability, rapid degradation, non-specific distribution, and frequent dosing requirements. To overcome these challenges, advanced carrier-based drug delivery systems have gained significant attention. These systems play a crucial role in protecting drugs from premature degradation or elimination, enhancing drug stability, controlling drug release, and increasing drug concentration at the target site. Among various novel vesicular carriers, niosomes have emerged as a promising and efficient drug delivery system. Niosomes are microscopic vesicles formed by the self-assembly of non-ionic surfactants in an aqueous medium, often stabilized by the incorporation of cholesterol. Due to their unique structural characteristics and physicochemical properties, niosomes are capable of encapsulating both hydrophilic and lipophilic drugs. Their biodegradability, biocompatibility, non-immunogenic nature, and chemical stability make them superior to many conventional and lipid-based delivery systems. This review provides a comprehensive overview of niosomal drug delivery systems, focusing on their introduction, definition, structural organization, and essential components. Detailed discussion is presented on the types of niosomes based on size, lamellarity, and method of preparation. The mechanism of drug entrapment and release, along with the mechanism of action, is elaborated to explain their role in targeted and controlled drug delivery. Various methods of preparation such as thin-film hydration, ether injection, reverse-phase evaporation, and microfluidization are discussed, along with factors affecting niosome formation, including surfactant type, cholesterol content, hydration temperature, and drug characteristics. Furthermore, this review highlights the physicochemical characterization of niosomes, including vesicle size, zeta potential, entrapment efficiency, surface morphology. comparative evaluation between niosomes and liposomes is also presented to emphasize the advantages of niosomes in terms of stability, cost-effectiveness, and ease of large-scale production. The advantages and disadvantages of niosomal systems are critically analyzed, followed by a detailed discussion on their therapeutic applications in drug targeting, transdermal delivery, cancer therapy, vaccine delivery, ophthalmic formulations, and controlled release systems. Overall, niosomes represent a versatile and promising carrier system with immense potential in improving drug delivery and therapeutic efficacy.

KEYWORDS: Niosomes, Non-ionic surfactant, Hydrophillc and Lipophillic drug, Cholesterol, Drug Delivery system, Hydration method.

INTRODUCTION

Currently, no drug delivery system can achieve precise site-specific delivery with controlled-release kinetics in a fully predictable manner. The concept of targeted drug delivery began in 1909 when Paul Ehrlich envisioned a method to deliver drugs directly to diseased cells. Since then, various carriers such as immunoglobulins, serum proteins, synthetic polymers, liposomes, microspheres, erythrocytes, and niosomes have been investigated for delivering drugs to specific organs or tissues.[1] Among these, liposomes and niosomes are well-studied. Drug targeting is defined as the ability to direct a therapeutic agent specifically to the desired site of action while minimizing interactions with non-target tissues.[2]

Niosomes are microscopic vesicles formed from a bilayer of non-ionic surfactants. They are extremely small, often on the nanometer scale, and are structurally similar to liposomes but differ in several aspects. Recent research has shown that niosomes can enhance transdermal drug delivery and serve as an advanced platform for targeted therapy.[3,4] Formed by the self-assembly of non-ionic surfactants and cholesterol in an aqueous phase, niosomes are biodegradable, biocompatible, and non-immunogenic. They exhibit high stability, long shelf life, and the ability to provide controlled or sustained drug delivery.[5]

The oral route is widely accepted as the most convenient method for drug administration.[6] However, many drugs face challenges including poor solubility, low oral bioavailability, enzymatic or gastric degradation in the gastrointestinal tract, extensive pre-systemic metabolism, limited absorption windows, and short residence time at absorption sites.[7] Strategies such as micronization, chemical modification, pH adjustment, solid dispersion, complexation, cosolvency, micellar solubilization, and hydrotropy are commonly used to improve solubility and bioavailability.[8]

Niosomal vesicles act as drug reservoirs, protecting drugs from acidic and enzymatic degradation in the gastrointestinal tract, thereby enhancing bioavailability compared to conventional dosage forms.[9] These vesicles are created when non-ionic surfactants self-assemble into closed bilayer structures in an aqueous medium.[10] Niosomes are easier to manufacture than some other vesicle-based systems, allowing efficient encapsulation of active pharmaceutical ingredients without complex covalent bonding. They also demonstrate advantages over liposomes in terms of stability and circulation half-life, as liposomes containing phospholipids are more prone to rapid phagocytosis and degradation, and the phospholipids are expensive.[11,12]

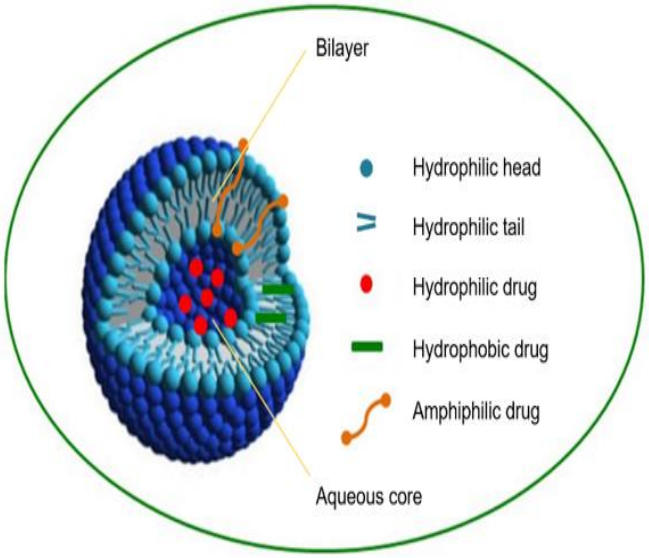
Conventional chemotherapy for intracellular infections often fails due to limited cellular uptake and off-target accumulation of drugs. Vesicular drug delivery systems, including niosomes, can enhance systemic availability and reduce off-target effects. Phagocytic uptake of drug-loaded vesicles provides an efficient mechanism to deliver drugs directly to the site of infection, potentially reducing toxicity and adverse effects.[13]

DEFINITION

A niosome is a non-ionic surfactant-based liposome.Niosomes are formed mostly by cholesterol incorporation as an excipient. Other excipients can also be used. Niosomes have more penetrating capability than the previous preparations of emulsions. They are structurally similar to liposomes in having a bilayer, however, the materials used to prepare niosomes make them more stable and thus niosomes offer many more advantages over liposomes.The size of niosomes are microscopic and lie in nanometric scale. The particle size ranges from 10nm-100nm.[14,15]

STRUCTURE OF NIOSOMES

Niosomes is a bilayered, spherical structure made of cholesterol and nonionic surfactant, with the hydrophobic end of the nonionic surfactant facing inwards (toward the lipophilic phase). The closed lipid bilayer that envelops solutes in the aqueous phase, which resembles the outer and inner surfaces of the hydrophilic area and sandwiched the lipophilic area in between, is created when the hydrophilic end faces outwards (toward the aqueous phase). These non-ionic surfactant-based vesicles, or "niosomes," are thought to be either a less expensive non-biological alternative to liposomes or possibly a drug delivery system that, in vivo, resembles liposomes but has particular properties to achieve different drug distribution and release characteristics.[16,17]



Figute 1: Structure of Niosomes.

COMPONENTS OF NIOSOMES

In the preparation of niosomes, two components is used:

1. Cholesterol
2. Non-ionic surfactants

A. Cholesterol provides structural rigidity, stability, and maintains the shape of niosomal vesicles while reducing membrane permeability.

B. Non-ionic surfactants are responsible for vesicle formation due to their amphiphilic nature and low toxicity.

Examples of surfactants:

Tween series: Tween 20, 40, 60, 80

Span series: Span 20, 40, 60, 80, 85.[18]

CHARACTERIZATION OF NIOSOMES

For successful clinical application, niosomal formulations require thorough characterization, as several parameters influence their in-vivo performance and stability. Key characterization attributes include vesicle morphology such as particle size and polydispersity index, number of bilayers (lamellarity), surface charge expressed as zeta potential, drug entrapment efficiency, and overall physical and chemical stability.[19]

Size

Niosomal vesicles are thought to have a spherical shape, and the laser light scattering method can be used to calculate their mean diameter[20] Additionally, electron microscopy, molecular sieve chromatography, ultracentrifugation, photon correlation microscopy, optical microscopy, and freeze fracture electron microscopy can all be used to measure the diameter of these vesicles. A fusion of vesicles during the cycle may be the cause of the increase in vesicle width caused by the freeze-thaw of Niosomes.[21,22]

Bilayer formation

Under light polarization microscopy, the creation of an X-cross indicates the assembly of non-ionic surfactants to create a bilayer vesicle.[23]

Number of lamellae

Small angle X-ray scattering, electron microscopy, and nuclear magnetic resonance (NMR) spectroscopy are used to ascertain this.[24]

Membrane rigidity

The mobility of a fluorescent probe as a function of temperature can be used to determine membrane stiffness.[25]

Entrapment efficiency

The unentrapped drug is separated after the niosomal dispersion is prepared, and the drug that is still entrapped in niosomes is identified by completely disrupting the vesicles with 50% n-propanol or 0.1% Triton X-100, then analyzing the resulting solution using the drug's suitable test method.[26] It can be shown as:

$$\text{Entrapment efficiency (EF)} = (\text{Amount entrapped} / \text{total amount}) \times 100$$

In vitro Release Study

Dialysis tubing was used to describe an in vitro release rate study technique.[27] After washing, distilled water was used to immerse a dialysis sac. After pipetting the vesicle suspension into a bag composed of the tubing, it was sealed. After that, the vesicle-containing bag was continuously shaken at 25°C or 37°C in a 250 ml beaker filled with 200 ml of buffer solution. Using a suitable assay technique, the buffer's drug content was examined at different intervals. In a different technique, isoniazid-encapsulated niosomes were separated using gel filtration on powdered Sephadex G-50 that had been swelled for 48 hours in double-distilled water.[28]

In vivo Release Study

For this study, albino rats were employed. These rats were separated into several groups. Using the proper disposal syringe, the niosomal suspension utilized in the in vivo investigation was administered intravenously (via the tail vein).[29]

TYPES OF NIOSOMES

The classification of niosomes is based on the size, size of the bilayers, and manufacturing method. The many niosome kinds are described in the paragraphs that follow.

A. Multi lamellar vesicles (MLV)
B. Large unilamellar vesicles (LUV)
C. Small unilamellar vesicles (SUV)[30]

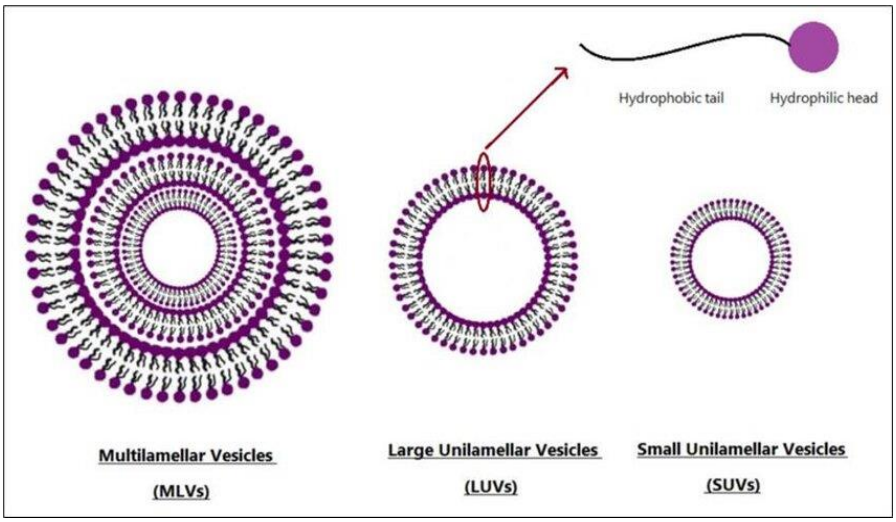


Figure 2: Types of Niosomes.

A. Multilamellar Vesicles (MLV)

The aqueous lipid compartment is surrounded by a number of bilayers. The diameter of these vesicles is approximately 0.5-10 µm. The most commonly used niosomes are multilamellar vesicles. It's easy to make and mechanically stable when held for a long time. Lipophilic compounds are well-suited to these vesicles as drug carriers.[31]

B. Large unilamellar vesicles (LUV)

Large unilamellar vesicles (LUVs) are characterized by a single lipid bilayer enclosing a relatively large internal aqueous core, and because of this high aqueous-to-lipid volume ratio, these niosomal systems are particularly effective in entrapping and retaining higher amounts of hydrophilic and bioactive substances, making them advantageous carriers for efficient drug delivery applications.[32]

C. Small Unilamellar Vesicles (SUVs)

Small unilamellar vesicles are nanosized vesicles consisting of a single lipid bilayer. They are commonly prepared by reducing multilamellar vesicles into smaller structures using techniques such as sonication, French press extrusion, or electrostatic precipitation, resulting in uniform and stable vesicles suitable for drug delivery applications.[33]

ANOTHER TYPE OF NIOSOME

A. Proniosomes

Proniosomes are made by covering a water-soluble carrier with a Narrow layer of non-ionic surfactant. The water-soluble carriers used to make proniosomes must be non-toxic, clean, free-flowing, and have to allow for good water solubility for easy hydration.

Proniosomes were made with sorbitol, maltodextrin, glucose monohydrate, mannitol, sucrose stearate, lactose monohydrate. Proniosomes come in a dry powder form and have many benefits over traditional niosomes, including greater durability, a lower likelihood of forming aggregates, and less drug leakage. Proniosomes can be made in a variety of ways, including slurry, slow spray coating, and coacervation phase separation.[34]

B. Elastic Niosomes

Elastic niosomes are niosomes that are flexible enough to move through pores smaller than their size without losing their structure. Surfactants, cholesterol, water, and ethanol are all components of these vesicles. Because of their ability to move through small pores and thus increase penetration through the skin barrier, they are widely used in topical or transdermal drug delivery.[35]

C. Discomes

Discomes are niosomes that look like big discs. Uchegbu and colleagues previously used mechanical agitation and sonication to prepare discomes from hexadecyl diglycerol ether, cholesterol, and dicetyl phosphate. They discovered that discomes were wide (11–60 μm) and that their size increased after sonication. Discomes are also thermoresponsive; as the temperature rises above 37 °C, their structure becomes less coordinated. Abdelkader et al. looked at discomes for naltrexone ocular delivery in the treatment of diabetic keratopathy.[36]

D. Bola Niosomes

Bola surfactants are used to make bola niosomes. In the early 1980s, this form of surfactant was discovered in the membrane of archaebacteria.They have two hydrophilic heads with one or two lipophilic linkers connecting them. Bola surfactants pusses the following Property a good assembling capacity, as evidenced by their much lower essential micelle concentration and higher surface tension than traditional surfactants, according to Zakharova (2010); further research revealed their tolerability in vitro and in vivo.[37]

E. Transfersomes

Transfersomes are deformable vesicular carrier systems that self-assemble into a lipid bilayer in an aqueous environment and close to form a vesicle. To increase permeability, lipid bilayer flexibility and a lipid bilayer softening component is added. it is also called as an edge activator. An edge activator is a non-ionic single-chain surfactant that allows the lipid bilayer to destabilise, enhancing its fluidity and elasticity.[38]

F. Aspasomes

Ascorbyl palmitate is a bilayer-forming substance that forms vesicles with ascorbyl palmitate, cholesterol, and a lipid which Having Negative Charge (dicetyl phosphate).The film hydration method is used to make aspsomes, which is then sonicated. Aspasomes have been investigated for transdermal delivery of active ingredients, and it has been discovered that they can improve transdermal penetration through the skin barrier. Azidothymidine (AZT)-loaded aspasomes were developed by Gopinath and colleagues for topical application.[39]

ADVANTAGES OF NIOSOMES

- Due to the amphiphilic structure of niosomes, a variety of pharmacological compounds can be soluble in them.
- When compared to oily dose forms, the water-based vesicle suspension delivers great patient compliance.
- The infrastructure of hydrophilic, lipophilic, and amphiphilic in niosomes allows for the accommodation of drug molecules with a wide spectrum of solubilities.
- By adjusting the composition of the vesicle, size lamellarity, surface charge, tapping volume, and concentration, vesicle properties can be changed.
- They have the ability to release the medicine gradually and deliberately.

- Because of the chemical stability of their structural makeup, surfactants can be stored and handled without the need for special conditions like low temperature and inert gas.
- They may function as depot formulations, allowing for regulated medication release.
- They increase the oral bioavailability of medications that aren't very soluble.
- They can protect the drug from enzyme metabolism.
- Extremely cost-effective for large-scale production.
- They are safe and made of non-toxic, biocompatible, and biodegradable materials.
- Niosomes guard the medication against enzymatic deterioration.
- They can be administered orally, parentally, topically, or transdermally.
- It may shield the medication from enzyme metabolism.[40,41,42]

DISADVANTAGES OF NIOSOMES

- The procedure takes a long time.
- Processing necessitates the use of specialized equipment.
- Due to the limited shelf life
- Cohesion
- Compilation
- Entrapped drug leakage
- Drugs that have been encapsulated are hydrolyzed[43,44]

COMPARISON BETWEEN NIOSOMES AND LIPOSOMES:[45,46]

NIOSOMES	LIPOSOMES
Vesicles formed from synthetic non-ionic surfactants.	Vesicular systems composed of natural phospholipids.
Bilayer structure made of non-ionic surfactants with cholesterol	One or more phospholipid bilayers enclosing an aqueous core
Synthetic non-ionic surfactants (e.g., Span, Tween series)	Mainly natural or semi-synthetic phospholipids
Usually smaller vesicles	Generally larger vesicles
More chemically stable and less prone to oxidation	Less stable due to susceptibility to oxidative degradation
Cholesterol is commonly incorporated for stabilization	Cholesterol may or may not be present
Generally less toxic	May show comparatively higher toxicity
Cost-effective and economical	Expensive due to purified phospholipids Cost-effective and economical
Do not require special storage conditions	Require special storage conditions
Suitable for hydrophilic, lipophilic, and amphiphilic drugs	Suitable for both hydrophilic and lipophilic drugs
Major applications-Gene delivery, tumor therapy, enzyme replacement therapy	Major applications-Transdermal, oral drug delivery, immunological adjuvants, diagnostics

MECHANISM OF ACTION OF NIOSOMES AS PERMEATION ENHANCER

Niosomes' ability to increase drug transfer through the skin has been attributed to a number of different mechanisms, including the alteration of the stratum corneum's barrier function as a result of reversible perturbation of lipid organisation, reduction of transepidermal water loss, which increases the stratum corneum's hydration and loosens its tightly packed cellular structure, and adsorption and/or fusion of niosomes. Three routes—intercellular, transcellular (paracellular), and transappendageal—can be used for drug transport across the stratum corneum, which is primarily a passive process. After it has travelled through the epidermis, a substance could be eliminated by thedeeper tissues may go through the dermal circulation.The effectiveness of various tactics has been evaluated toenhance the stratum

corneum's barrier function of drug penetration of the skin. Penetration improvement in particular one or more of the following three mechanisms could be used by ers to act. Niosomes can lengthen the period that a medication stays in the SC and epidermis when given topically they are believed to enhance the smoothness and characteristics of the horny layer by restoring lost skin lipid and minimising transepidermal water loss.[47,48,49]

METHODS OF PREPARATION OF NIOSOMES

The method adopted for niosome preparation has a decisive influence on the resulting vesicle size, lamellarity, entrapment efficiency, surface charge, and long-term stability. Parameters such as the ratio of surfactant to cholesterol, solvent polarity, hydration temperature, and agitation speed collectively determine the morphology and drug-loading capacity of the final formulation. Selecting an appropriate technique therefore becomes essential to achieve the desired physicochemical and therapeutic performance of the niosomal system.[50]

A. Thin-Film Hydration Method:

This is the most conventional and widely employed technique for niosome production. A mixture of non-ionic surfactant (typically Span or Tween derivatives) and cholesterol is dissolved in an organic solvent such as chloroform or a chloroform–methanol blend. The solvent is evaporated under reduced pressure using a rotary evaporator to form a uniform thin film on the inner wall of a round-bottom flask. The dry film is then hydrated with an aqueous phase containing the drug, usually at a temperature above the gel–liquid transition of the surfactant. Agitation causes the film to swell and detach, producing multilamellar vesicles (MLVs). Further size reduction by probe or bath sonication yields small unilamellar vesicles (SUVs).

Advantages: simple and reproducible, suitable for both hydrophilic and lipophilic drugs.

Limitations: may yield heterogeneous size distribution and comparatively low entrapment for hydrophilic drugs[51,52]

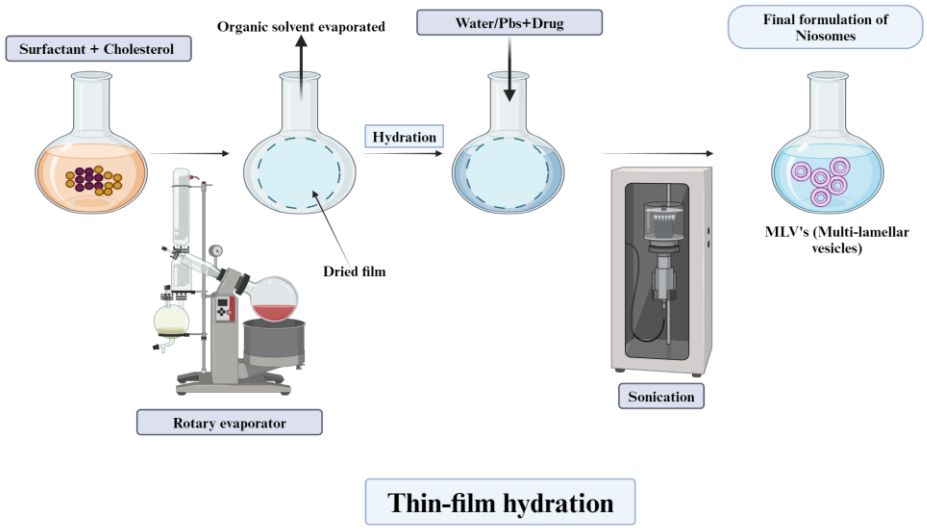


Figure 3: Thin-film hydration method.

B. Reverse-Phase Evaporation (REV) Method

The REV approach for niosome preparation is mainly desired in order to encapsulatehydrophilic payload, as it ensures a more highly aqueous core than the film hydrationmethod. The REV approach requires mixing cholesterol and

surfactant in a mixture of etherand chloroform. An aqueous solution containing payload is added, and the two phasesthat form are sonicated for 5 min at 4–5 ◦C. The clear gel that is formed is further soni-cated following the addition of approximately 10 mL of aqueous phase, after which theorganic phase is removed under low pressure at ~40 ◦C using a rotary evaporator. Theresulting viscous suspension is diluted with an aqueous phase and heated in a water bath at temperatures above the Tc for 10 min to yield niosomes The main drawback of this technique is the possibility of the presence of residual solvent, which may result in unintended biological effects.[53,54]

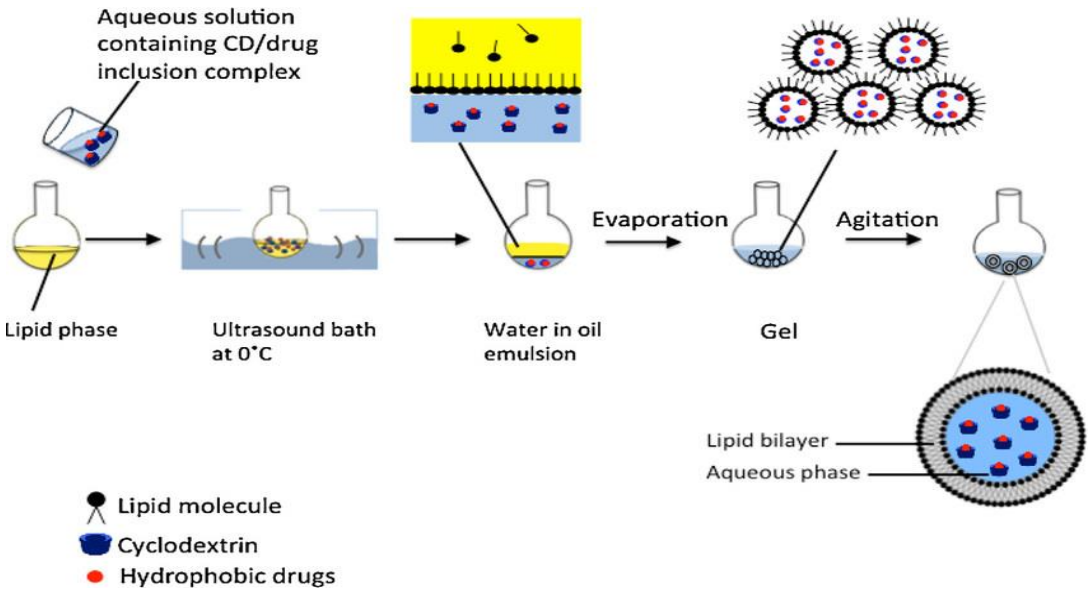


Figure 4: Reverse-Phase Evaporation (REV) Method.

C. Ether-Injection Method

This method provides a means of making niosomes by slowly introducing a solution of surfactant dissolved in diethyl ether into warm water maintained at 70°C. The surfactant mixture in ether is injected through 148 gauge needle into an aqueous solution of material. Vaporization of ether leads to formation of single layered vesicles. Depending upon the conditions used the diameter of the vesicle range from 50 to 1000 nm.[55]

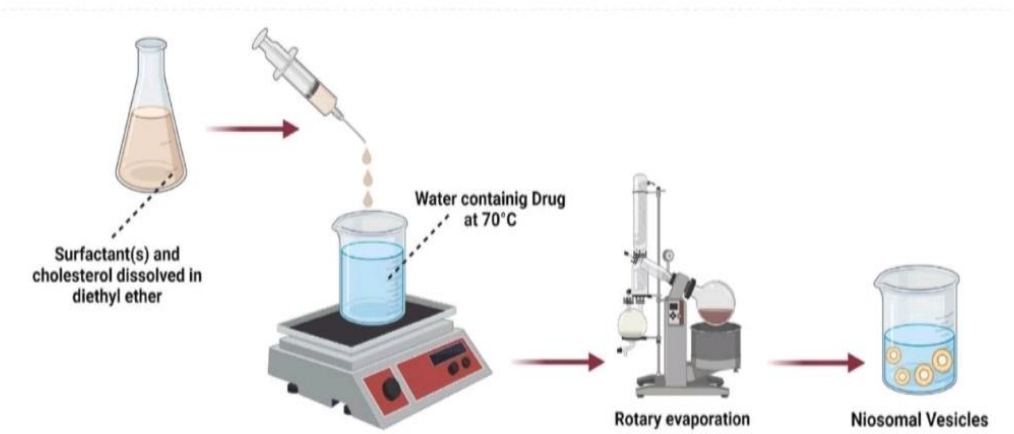


Figure 5: Ether Injection Method.

D. Sonication Method

Sonication is a popular technique for producing noisome vesicles. A 10-ml glass vial containing the drug, cholesterol, and surfactants is opened, and the contents are mixed with buffer. In order to produce Niosomes, the liquid is then sonicated with a titanium probe for around three minutes. Tiny, unilamellar vesicles are present in the finished product. Making small vesicles is the most popular use of this technique. Probe and bath sonicators are the two types used in the sonication process. Depending on the circumstance, either kind may be used.[56]

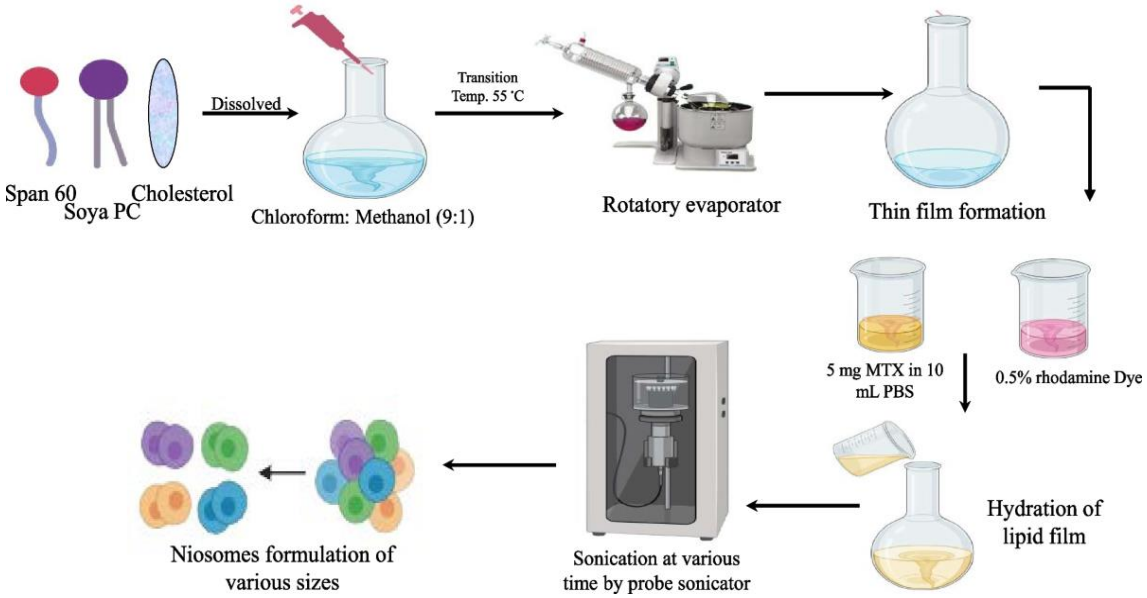


Figure 6: Sonication method.

E. Microfluidization (High-Pressure Homogenization)

This modern technique forces two immiscible phases: organic and aqueous, throughmicrochannels at high pressure to generate uniform vesicles via controlled shear. Microfluidization offers excellent reproducibility, scalability, and narrow particle-size distribution. It is particularly useful for industrial production of niosomal formulations intended for parenteral use.[57,58]

F. The "Bubble" Method

In this method, surfactants, additives, and the buffer are added into a glass flask with three necks. Niosome components are dispersed at 70∘C and the dispersion is mixed with homogenizer. After that, immediately the flask is placed in a water bath followed by the bubbling of nitrogen gas at 70∘C. Nitrogen gas is passedthrough a sample of homogenized surfactants resulting information of large unilamellar vesicles.[59]

G. Heating method

An invention by Mozafari et al. has been patented. Cholesterol can be dissolved by hydrating surfactants in a buffer and heating it to 120°C. As the cholesterol dissolves in the buffer, the surfactants and other chemicals are added and mixed in. At this stage, niosomes are formed and kept under nitrogen at 4-5°C until needed.[60]

H. Emerging Techniques

Recent research has introduced advanced fabrication methods that provide greater control over vesicle size and minimize solvent exposure.

1. Microfluidic Chip Synthesis: This automated process combines surfactant and aqueous streams in micro-channels, allowing real-time control of mixing rate and particle size. It ensures reproducibility and is compatible with temperature-sensitive bio actives.
2. Supercritical CO_2-Assisted Assembly: A green technique that replaces organic solvents with supercritical carbon dioxide as a dispersion medium. The rapid depressurization of CO_2 induces self-assembly of surfactant molecules into niosomal vesicles. This process is clean, rapid, and scalable, aligning with modern environmental and safety standards[53,61]

EVALUATION OF NIOSOMES

A. Determination of Production Yield

Determination of production yield is done for determination of efficiency by using following formula: - Determination of production yield = Practical yield / Theoretical yield × 100.

B. Actual Drug Content and Entrapment Efficiency

Actual drug content and efficiency done by Niosomes centrifugation, then free drug taking place in centrifugation technique, separated drug then use for spectroscopy technique for its confirmation.

C. Infrared Spectroscopy

To check the functional group of drug, infrared spectroscopy is using to check any interaction between drug and additives through spectrogram.

D. Differential Scanning Colorimetry

Thermal analysis of pure drug, span 60, cholesterol and drug loaded niosomes carry out with a differential scanning calorimeter. Thermogram gives us idea about drug excipients.

E. Scanning Electron Microscopy

scanning electron microscopy gives us all the surface morphology information and also to find the physical morphology of individual particle by the scanning electron microscopy.

F. Transmission Electron Microscopy

Transmission electron microscopy done for to checking internal morphology, characteristics of niosomes. Transmission microscopy gives idea about the internal characteristics of our formulations.

G. Zeta Potential

The charges on the vesicular surface will be measured using the zeta potential apparatus at 25 °C using a combination of laser Doppler velocimetry and phase analysis light scattering.[62-66]

FACTORS AFFECTING NIOSOME FORMATION

A. Drug

The charge and rigidity of the niosomal bilayer are directly affected by the physicochemical properties of the encapsulated drug. The vesicle size of the niosomes is increased by entrapping the drug within the niosomes, as well as by solute interaction with surfactant head groups.[67]

B. Resistance of osmotic stress

The addition of hypertonic salt solution to the niosomal suspension causes a decrease in niosomal diameter. Again, the addition of hypotonic salt solution causes slow release with slight swelling of the vesicles due to the inhibition of vesicle elution fluid[68]

C. Temperature of hydration medium

The temperature of the hydration medium is critical in the formation of vesicles. This has an impact on their shape and size. The temperature should be kept above the system's gel to liquid phase transition temperature. Temperature also causes changes in the shape of the vesicle.[69]

D. Cholesterol

The presence of cholesterol in niosomes increases their hydrodynamic diameter and entrapment efficiency. It influences the membrane properties of niosomes in the same way that it influences the properties of biological membranes.[70]

E. Amount and Type of Surfactant

Because the surface free energy of a surfactant decreases with increasing hydrophobicity, the mean size of niosomes increases proportionally with increasing HLB surfactants such as Span 85 (HLB 1.8) to Span 20 (HLB 8.6). Depending on the temperature, the type of surfactant, and the presence of other components such as cholesterol, the bilayers of the vesicles are either liquid or gel. In the gel state, alkyl chains have a well-ordered structure, whereas in the liquid state, the structure of the bilayers is more disordered. The gel-liquid phase transition temperature of surfactants and lipids distinguishes them (TC).[71]

F. Charge

The vesicle's charge increases the interlamellar distance between successive bilayers in a multilamellar vesicle structure, as well as the overall entrapped volume and stability of niosomes[72]

G. Composition of the membrane

The addition of completely different additives to the surfactant mixture can result in the stabilization of niosomes. The main disadvantage of niosome formulation is drug leakage from the vesicles, which may be controlled by the addition of cholesterol.[73]

MARKETED FORMULATION OF NIOSOMES

Sr. No.	Brand Name	Name of the Product
1.	Lancôme-Foundation and complexation	Flash Retouch Brush on Concealer
2.	Britney Spears-Curious	Curious coffret: Edp Spray 100ml +Dualended Parfum & pink lipgoss + Body souffle 100 ml
3.	Orlane – Lipcolor and Lipstick	Chrome Eau De Toilette Spray 200 ml
4.	Orlane – Lipcolor and Lipstick	Lip Gloss

APPLICATIONS OF NIOSOMES

A. Targeting of bioactive agents

i) To reticulo-endothelial system (RES)

The cells of RES preferentially take up the vesicles. The uptake of niosomes by the cells is also by circulating serum factors known as opsonins, which mark them for clearance. Such localized drug accumulation has, however, been exploited in treatment of animal tumors known to metastasize to the liver and spleen and in parasitic infestation of liver.[74]

ii) To organs other than RES

It has been suggested that carrier system can be directed to specific sites in the body by use of antibodies. Immunoglobulins seem to bind quite readily to the lipid surface, thus offering a convenient means for targeting of drug carrier.Many cells possess the intrinsic ability to recognize and bind particular carbohydrate determinants and this can be exploited to direct carriers system to particular cells.[75,76]

B. Neoplasia

Doxorubicin, the anthracyclic antibiotic with broad spectrum anti tumor activity, shows a dose dependant irreversible cardio toxic effect. Niosomal delivery of this drug to mice bearing S-180 tumor increased their life span and decreased the rate of proliferation of sarcoma(38). Niosomal entrapment increased the half-life of the drug, prolonged its circulation and altered its metabolism. Intravenous administration of methotrexate entrapped in niosomes to S-180 tumor bearing mice resulted in total regression of tumor and also higher plasma level and slower elimination[77,78]

C. Theranostic and Imaging Applications

An emerging field involves theranostic niosomes, combining therapeutic and diagnostic capabilities within a single platform. Quantum-dot- or dye-labeled pH-responsive niosomes enable simultaneous imaging and drug release, allowing real-time visualization of biodistribution and treatment progress. This dual-function approach enhances precision and supports the advancement of personalized cancer nanomedicine.[61]

D. Co-delivery and Multidrug-Resistance (MDR) Management

Niosomes are highly effective in the co-delivery of multiple chemotherapeutic agents, enhancing therapeutic synergy and overcoming drug resistance. The pH-sensitive co-delivery of doxorubicin and camptothecin enabled sequential release, maximizing cancer-cell apoptosis. Furthermore, PEGylation or folate modification enhances circulation time and receptor-mediated uptake, providing a means to bypass efflux transporters responsible for MDR. Such platforms are being investigated for refractory tumors including breast, lung, and hepatic cancers.[79]

E. Gene and Protein Delivery

pH-responsive niosomes also serve as efficient carriers for genetic and protein therapeutics. During intracellular trafficking, endosomal acidification (pH ≈ 5.5) induces vesicle destabilization, releasing the encapsulated biomolecules into the cytoplasm and preventing lysosomal degradation. This mechanism improves transfection efficiency and facilitates the delivery of peptides, siRNA, or plasmid DNA valuable for emerging gene-based anticancer strategies.[57,80]

F. Antibiotics

Non-ionic surfactant vesicles (niosomes) are used as a carrier for the ophthalmic administration of a water-soluble local antibiotic. Gentamicin sulphate was studied, and the results showed that niosomes are promising ophthalmic carriers for gentamicin sulphate topical application.[81]

G. Cosmetics

The first report of non-ionic surfactant vesicles came from L'Oreal's cosmetic applications. L'Oréal invented and patented niosomes in the 1970s and 1980s. Lancôme launched its first product, 'Niosome,' in 1987. The ability of niosomes to increase the stability of entrapped drugs, improve bioavailability of poorly absorbable ingredients, and improve skin penetration are all advantages in cosmetic and skin care applications.[82]

H. Other Biomedical Applications

Beyond oncology, pH-responsive niosomes show promise in antimicrobial, antifungal, anti-inflammatory, and ocular drug delivery, where infection- or inflammation-induced acidity facilitates localized drug release. These systems improve bioavailability and reduce systemic side effects, demonstrating the versatility of niosomal technology across therapeutic areas.[57,80]

CONCLUSION

In recent years, vesicular drug delivery systems such as liposomes and niosomes have received considerable research interest. Among these systems, niosomes have emerged as a preferable alternative to liposomes due to their improved stability, lower cost, and better formulation flexibility. Niosomes provide an efficient platform for prolonged, targeted, and controlled drug delivery and are capable of encapsulating both hydrophilic and lipophilic drugs. Furthermore, advancements in formulation techniques, drug loading strategies, and surface modification approaches can further enhance the therapeutic potential of niosomes. Therefore, continued research and development in these areas are essential to fully exploit niosomes for advanced pharmaceutical applications.

REFERENCES

1. Theresa M.A., Drugs published by Adis international Ltd., 1998; 56(5): 747-756.
2. Breimer D.D. and Speiser R. Topics in pharmaceutical Sciences. 5 Elsevier Science Publishers, New York, USA, 1985; p.291.
3. Abdelbary G, El-Gendy N., Niosome-encapsulated gentamicinor ophthalmic controlled delivery. AAPS Pharm Sci Tech, 2008; 9: 740–747.
4. Talegaonkar, S.; Mishra, P.; Khar, R.; Biju, S. Vesicular systems: An overview. Indian J. Pharm. Sci., 2006; 68: 141.
5. Mahale NB, Thakkar PD, Mali RG, Walunj DR, Chaudhari SR. Niosomes: Novel sustained release nonionic surfactant-based vesicular drug delivery system. Pharmaceutics, 2012; 4(1): 1–28.
6. Thabet Y, Elsabahy M, Eissa NG. Methods for preparation of niosomes: A focus on thin-film hydration method. Methods, 2021; 199: 1-7.
7. Babadi D, Dadashzadeh S, Osouli M, Abbasian Z, Daryabari MS, Sadrai S, et al. Biopharmaceutical and pharmacokinetic aspects of nanocarrier-mediated oral delivery of poorly soluble drugs. J Drug Deliv Sci Technol, 2020; 62: 1-35.

8. Vemula VR, Lagishetty V, Lingala S. Solubility enhancement techniques. Int J Pharm Sci Rev Res, 2010; 5: 41-51.
9. Bagheri A, Chu BB, Yaakob H. Niosomal drug delivery systems: Formulation, preparation and applications. World Appl Sci J, 2014; 32: 1671-85.
10. Linta V, Daisy PA, Johns GB, Raj RP, Thomas N. Niosomal drug delivery system: Formulation and applications. W J Pharm Med Res, 2017; 3: 109-15.
11. Uchegbu, I.F.; Vyas, S.P. Non-ionic surfactant based vesicles (niosomes) in drug delivery. Int. J. Pharm, 1998, 172, 33–70. [CrossRef]
12. Marianecci, C.; Di Marzio, L.; Rinaldi, F.; Celia, C.; Paolino, D.; Alhaique, F.; Esposito, S.; Carafa, M. Niosomes from 80s to present:The state of the art. Adv. Colloid Interface Sci., 2014; 205: 187–206. [CrossRef]
13. Moghassemi, S.; Hadjizadeh, A. Nano-niosomes as nanoscale drug delivery systems: An illustrated review. J. Control. Release, 2014; 185: 22–36. [CrossRef]
14. Khandare JN, Madhavi G, Tamhankar BM. Niosomes: Novel drug delivery system. The Eastern Pharmacist, 1994; 37: 61–64.
15. Baillie AJ, Florence AT, Hume LR, Muirhead GT, Rogerson A. The preparation and properties of niosomes: Non-ionic surfactant vesicles. Journal of Pharmacy and Pharmacology, 1985; 37: 863–868.
16. Bangham, A.D. Surrogate Cells or Trojan Horses: The Discovery of Liposomes. BioEssays, 1995; 17: 1081–1088.
17. Singh, D.; Pradhan, M.; Nag, M.; Singh, M.R. Vesicular system: Versatile carrier for transdermal delivery of bioactives. Artif. Cells Nanomed. Biotechnol, 2015; 43: 282–290
18. Uchegbu IF, Vyas SP.Non-ionic surfactant based vesicles (niosomes) in drug delivery.International Journal of Pharmaceutics, 1998; 172(1–2): 33–70.
19. Carafa M, Santucci, E., Lucania, G. Lidocaine-loaded non-ionic surfactant vesicles: characterization and in vitro permeation studies. Int J Pharm, 2002; 231: 21–32.
20. Sergio Liga, Niosomes: Composition, Formulation Techniques, and Recent Progress as Delivery Systems in Cancer Therapy, MDPI Pharmaceutics, 2024; 16: 223
21. Mahmoud Gharbavi, Jafar Amani, Niosome: A Promising Nanocarrier for Natural Drug Delivery through Blood-Brain BarrierAdvances in Pharmacological Sciences, 2018. Article ID 6847971,15.109
22. Ali Nasir, Harikumar SL and Kaur Amanpreet, Niosomes: An excellent tool for drug delivery. IJRPC; 2012; 2(2): 2231-2781.
23. Ge X, Wei M, He S, Yuan WE. Advances of Non-Ionic Surfactant Vesicles (Niosomes) and Their Application in Drug Delivery. Pharmaceutics, 2019; 11(2): 55. doi: 24.3390/pharmaceutics11020055. PMID: 30700021; PMCID: PMC 6410054.
24. Linta V., Daisy P.A., Boby Johns G., Niosomal drug delivery system: Formulation and applications. WJPMR; 2017; 3(5): 109-115.
25. Seth G.L.Bihani, Niosomes: A New Approach to Targeted Drug Delivery International Journal of Pharmaceutical and Phytopharmacological Research, 2012; 53: 2249 –6084.
26. Dharashive VM, Kapse Vidya, Niosomes: As a targeted drug delivery system. IJRPC, 2015; 5(4): 582-589.
27. Devender Sharma, Aashiya Aara E. Ali, Jayshree R. Aate. Niosomes as Novel Drug Delivery System: Review Article. magazine.pharmatutor.org, 2019; 6(3): 90-93.

28. Vrunal V. More, Ritu M, Niosomal Drug Delivery -A Comprehensive Review. Asian Journal of Pharmaceutics, 2018 Oct-Dec; 12(4): S11.
29. Tangri P, Khurana S, Niosomes: Formulation and evaluation, Int J Biopharma, 2011; 2(1): 47-53.
30. Singh D, Upadhyay P. Niosomes: A novel vesicular approach. World Journal of Pharmacy and Pharmaceutical Sciences, 2016; 5(12): 1586–1592.
31. Moghassemi S, Hadjizadeh A. Nano-niosomes as nanoscale drug delivery systems: an illustrated review. Journal of Controlled Release, 2014; 185: 22–36.
32. Sonule M, Gandhi M, Paralkar S, Dabhade D, Pagar S. Niosomes: novel drug delivery system. Int J Pure App Bio Sci., 2014; 2(2): 267-274.
33. Mozafari, M. R. Liposomes: An overview of manufacturing techniques. Cellular & Molecular Biology Letters, 2005; 10(4): 711–719.
34. Madhav N VS, Saini A Niosomes: a novel drug delivery system. International journal of research in pharmacy and chemistry, 2011; 1: 498-511.
35. Chen S, Hanning S, Falconer J, Locke M, Wen, J Recent advances in non-ionic surfactant vesicles (niosomes): Fabrication, characterization, pharmaceutical and cosmetic applications. European Journal of Pharmaceutics and Biopharmaceutics, 2019; 144: 18-39.
36. Ibrahim MM, Shehata TM The enhancement of transdermal permeability of water-soluble drug by niosome-emulgel combination. Journal of drug delivery science and technology, 2012; 22: 353-359.
37. Manosroi A, Jantrawut P, Manosroi J Anti-inflammatory activity of gel containing novel elastic niosomes entrapped with diclofenac diethylammonium. International journal of pharmaceutics, 2008; 360: 156-163.
38. Manosroi A, Chankhampan C, Manosroi W, Manosroi J Transdermal absorption enhancement of papain loaded in elastic niosomes incorporated in gel for scar treatment. European Journal of Pharmaceutical Sciences, 2013; 48: 474-483.
39. Abdelkader H, Ismail S, Kamal A, Alany RG Design and evaluation of controlled-release niosomes and discomes for naltrexone hydrochloride ocular delivery. Journal of pharmaceutical sciences, 2011; 100: 1833-1846.
40. Sonule M, Gandhi M, Paralkar S, Dabhade D, Pagar S. Niosomes: novel drug delivery system. Int J Pure App Bio Sci., 2014; 2(2): 267-74.
41. Parmar RP, Parmar RB. Conceptual aspects of vesicular drug delivery system with special reference to niosome. Asian J Pharm Tech, 2013; 3(2): 52-59.
42. Chandu VP, Arunachalam A, Jeganath S, Yamini K, Tharangini K, Chaitanya G. Niosomes: a Novel drug delivery system. Int J novel trends Pharm Sci., 2012; 2(1): 25-31.
43. Usman MRM, Ghuge PR and Jain BV. Niosomes: a novel trend of drug delivery. European Journal of Biomedical and Pharmaceutical Sciences, 2017; 4(7): 436-442.
44. Sharma D, Ali AAE, Aate JR. Niosomes as novel drug delivery system: review article. PharmaTutor, 2018; 6(3): 58-65. 17. https://doi.org/10.29161/PT.v6.i3.2018.58
45. Kazi, K. M., Mandal, A. S., Biswas, N., Guha, A., Chatterjee, S., Behera, M., & Kuotsu, K. Niosome: A future of targeted drug delivery systems. Journal of Advanced Pharmaceutical Technology & Research, 2010; 1(4): 374–380.
46. Allen, T. M., & Cullis, P. R. Liposomal drug delivery systems: From concept to clinical applications.Advanced Drug Delivery Reviews, 2013; 65(1): 36–48.

47. Manconi M, Sinico C, Valenti D, Lai F, Fadda AM. Niosomes as car-riers for tretinoin. III. A study into the in vitro cutaneous delivery of vesicle-incorporated tretinoin. Int J Pharm, 2006; 27: 11–19
48. Abdelkader H, Alani AW, Alany RG. Recent advances in non-ionic surfactant vesicles (niosomes): self-assembly fabrication, characteriza-tion, drug delivery applications and limitations. Drug Deliv, 2014; 21: 87–100.
49. Mali N, Darandale S, Vavia P. Niosomes as a vesicular carrier for topi-cal administration of minoxidil: formulation and in vitro assessment. Drug Deliv Transl Res, 2013; 3: 587–592.
50. Liga, S., Paul, C., Moacă, E. A., & Péter, F. Niosomes: Composition, formulation techniques, and recent progress as delivery systems in cancer therapy. Pharmaceutics, 2024; 16(2): 223. https://doi.org/10.3390/pharmaceutics16020223
51. Shewaiter, M. A., Selim, A. A., Rashed, H. M., Moustafa, Y. M., & Gad, S. Niosomes as a novel pharmaceutical carrier: Structure, classification, and preparation methods. AAPS PharmSciTech, 2024; 25(2): 2906. https://doi.org/10.1208/s12249-024-02906-7
52. Zaer, H., et al. pH-responsive doxorubicin niosomal composite. International Journal of Biologicals Macromolecules, 2024; 247: 126–139. https://doi.org/10.1016/j.ijbiomac.2024.123456
53. Baillie, A.J.; Florence, A.T.; Hume, L.R.; Muirhead, G.T.; Rogerson, A. The preparation and properties of niosomes—non-ionic surfactant vesicles. J. Pharm. Pharmacol, 1985; 37: 863–868.
54. Szoka, F.; Papahadjopoulos, D. Procedure for preparation of liposomes with large internal aqueous space and high capture by reverse-phase evaporation. Proc. Natl. Acad. Sci. USA, 1978; 75: 4194–4198.
55. T. Yoshioka, B. Sternberg, and A. T. Florence, “Preparationand properties of vesicles (niosomes) of sorbitan monoesters (Span 20, 40, 60 and 80) and a sorbitan triester (Span 85),”International Journal of Pharmaceutics, 1994; 105(1): 1–6.
56. Kazi Masud Karim, Niosome: A future of targeted drug delivery systems Journal of Advanced Pharmaceutical Technology & Research, 2010; 1(4): 89-93
57. Witika, B. A., Bassey, K. E., Demana, P. H., Siwe-Noundou, X., & Poka, M. S. Current advances in specialised niosomal drug delivery: Manufacture, characterization and drug delivery applications. International Journal of Molecular Sciences, 2022; 23(17): 9668. https://doi.org/10.3390/ijms23179668
58. Aparajay, P., & Dev, A. Functionalized niosomes as a smart delivery device in cancer and fungal infection. *European Journal of Pharmaceutical Sciences, 2022; 168: 106052. https://doi.org/10.1016/j.ejps.2021.106052
59. H. Talsma, M. J. Van Steenbergen, J. C. H. Borchert, and D. J.A. Crommelin, “A novel technique for the one-step preparationof liposomes and nonionic surfactant vesicles without theuse of organic solvents. Liposome formation in a continuous gas stream: the ‘bubble’ method,” Journal of Pharmaceutical Sciences, 1994; 83(3): 276–280.
60. P.U.Mohamed Firthouse SMH, S.U.Wahab, M.Sirajudeen, S.Kadher Mohideen. Formulation and Evaluation of Miconazole Niosomes. International Journal of PharmTech Research, 2011; 3.
61. Barani, M., Mirzaei, M., Torkzadeh-Mahani, M., Lohrasbi-Nejad, A., & Nematollahi, M. H. A new formulation of hydrophobin-coated niosome as a drug carrier to cancer cells. *Materials Science and Engineering: C, 2020; 113: 110975. https://doi.org/10.1016/j.msec.2020.110975
62. Ramkanth S, Chetty CM, Sudhakar Y, Thiruvengadarajan VS, Anitha P et al. Development, characterization & invivo evaluation of proniosomal based transdermal delivery system of Atenolol. Future Journal of Pharmaceutical Sciences, 2018; 4: 80-87.

63. Muzzalupo R, Tavano L, Cassano R, Trombino S, Ferrarelli T, et al. A new approach for the evaluation of niosomes as effective transdermal drug delivery systems. European Journal of Pharmaceutics and Biopharmaceutics, 2011; 79: 28-35.
64. Rajesh Z Mujoriya, Kishor Dhamande, Dr Ramesh Babu Bodla Niosomal Drug Delivery System – A Review, International Journal of Applied Pharmaceutics, 2011; 3: 7-10.
65. Mujoriya RZ, Bodla R Niosomes–challenge in preparation for pharmaceutical scientist. Int J App Pharm, 2011; 3: 11-15
66. Rajera R, Nagpal K, Singh SK, Mishra DN Niosomes: a controlled and novel drug delivery system. Biological and Pharmaceutical Bulletin, 2011; 34: 945-953.
67. Sharma P, Jain AP, Pandey P, Gupta R, Roshan S. Niosome a novel approach for drug delivery system: an overview. Asian Journal of Pharmaceutical science and Research, 2013; 3(5): 18- 30.
68. Vadlamudi CH, Sevukarajan M. Niosomal drug delivery systema review. Indo American Journal of Pharmceutical Research, 2012; 2(9)
69. Kauslya A, Borawake PD, Shinde JV, Chavan RS, Niosomes: A Novel Carrier Drug Delivery System, Journal of Drug Delivery and Therapeutics, 2021; 11(1): 162-170 https://doi.org/10.22270/jddt.v11i1.4479
70. Kumavat S, Sharma PK, Koka SS, Sharma R, Gupta A, Darwhekar GN, A Review on Niosomes: Potential Vesicular Drug Delivery System, Journal of Drug Delivery and Therapeutics, 2021; 11(5): 208-212. https://doi.org/10.22270/jddt.v11i5.5046
71. Sakthivel M, Kannan K, Manavalan, Senthamarai. Non-ionic surfactant vesicles-a review. Research Journal of Pharmaceutical, Biological and Chemical, 2012; 3(1): 604-614.
72. Vadlamudi HC, Sevukarajan M, "Niosomal drug delivery- a review" IAJPR, 2012; 2(9).
73. Patel H, .Patel U, "Review on niosomes - a novel approach for drug targeting" IJAP, 2019; 08(01): 1-6.
74. Malhotra M. and Jain N.K. Niosomes as Drug Carriers. Indian Drugs, 1994; 31(3): 81-86.
75. Gregoriadis G. Targeting of drugs: implications in medicine. Lancet, 1981; 2(8240): 241-246.
76. Weissman G., Bloomgarden D., Kaplan R., Cohen C., Hoffstein S., Collins T., Gotlieb A. and Nagle D. A general method for the introduction of enzymes, by means of immunoglobulin-coated liposomes, into lysosomes of deficient cells. Proc. Natl. Acad. Sci., 1975; 72(1): 88-92.
77. Chandraprakash K.S., Udupa N., Umadevi P. and Pillai G.K. Formulation and evaluation of Methotrexate niosomes. Ind. J. Pharm. Sci., 1992; 54(5): 197.
78. Suzuki K. and Sokan K. The Application of Liposomes to Cosmetics. Cosmetic and Toiletries, 1990; 105: 65-78.
79. Aparajay, P., & Dev, A. Functionalized niosomes as a smart delivery device in cancer and fungal infection. *European Journal of Pharmaceutical Sciences, 2022; 168: 106052. https://doi.org/10.1016/j.ejps.2021.106052
80. Zayed, D. G., AbdElhamid, A. S., Freag, M. S., & Elzoghby, A. O. Hybrid quantum dot- based theranostic nanomedicines for tumor-targeted drug delivery and cancer imaging. Nanomedicine, 2019; 14(3): 225–228. https://doi.org/10.2217/nnm-2018-0414
81. Pawar P, Sankhyan A. Recent trends in niosome as vesicular drug delivery system. Journal of Applied Pharmaceutical Science, 2012; 2(6): 20-32.
82. Verma NK, Roshan A, Niosomes and Its Application-A Review, IJRPLS, 2014; 2(1):182-184.