JOURNAL OF PHYSICS AND CHEMISTRY
Review Article
Volume 2 | Issue 3

Niosomes – A Novel Carrier for Drug Delivery

A Krishna Sailaja

Chelsea Ruth John and Abbaraju Krishna Sailaja, Department of Pharmaceutics, Rbvrr Women's College of Pharmacy, Affiliated to Osmania University, Hyderabad.

***Corresponding Author:** A Krishna Sailaja, Chelsea Ruth John and Abbaraju Krishna Sailaja, Department of Pharmaceutics, Rbvrr Women's College of Pharmacy, Affiliated to Osmania University, Hyderabad.

Submitted: 15 Feb 2024 **Accepted:** 19 Feb 2024 **Published:** 24 Feb 2024

Citation: *A Krishna Sailaja (2024). Niosomes – A Novel Carrier for Drug Delivery J of Physics & Chemistry. Review Article. 2(3).1-10.*

Abstract

The goal of novel drug delivery is to either maintain drug activity at a predetermined rate or to keep the body's effective drug level roughly constant while minimizing any adverse effects. It is also possible to target drug action by utilizing carriers or chemical derivatization to deliver the drug to a specific target cell type, or it is possible to localize drug activity by the spatial placement of controlled release systems adjacent to or within the diseased tissue or organ. When Paul Ehrlich envisioned a drug delivery system that would target specifically damaged cells, he launched the period of development for targeted delivery in 1909 (Magic bullet). Drug targeting is the ability of a therapeutic substance to be directed directly to intended site of action with little or no interaction with non-target tissue. In these various carriers are used to deliver the drug to target site. Niosomes are non-ionic surfactant vesicles that were initially developed in 1985 by Ballie et al. Niosomes are concentric bilayered vesicles that completely encapsulate an aqueous volume with a membranous lipid bilayer composed primarily of cholesterol and non-ionic surfactants. These are similar to liposomes which can entrap both hydrophilic and hydrophobic drugs. In this article niosomal formulation and applications were discussed in detail.

Keywords: Surfactant, Cholesterol, Lamellar Structure, Thin Film Hydration Technique, Permeation Studies.

Introduction

Whether this control is of a temporal, spatial, or combined form, the goal of novel drug delivery systems is to offer some control amount of drug release in the body.Pharmaceutical carriers come in a variety of forms, including particulate, polymeric, macromolecular, and cellular. Lipid particles, microspheres, nanoparticles, polymeric micelles, and other small particles are examples of the particulate type carrier, often known as the colloidal carrier system, and vesicular structures like liposomes, sphingosomes, niosomes, transferosomes, pharmacosomes, and virosomes. Certain amphiphilic building blocks are exposed to water, resulting in the formation of vesicular systems, which are highly organised assemblies of one or more concentric lipid bilayers. Many different types of amphiphilic building blocks can be used to create vesicles. The Bingham bodies were initially described as having a biological origin by Bingham in 1965 (Bangham et al., 1965). Due to the limited drugs penetration into cells, conventional chemotherapy is ineffective for treating intracellular infections. Vesicular drug delivery devices can be used to bypass this [1-2].

Niosomes are concentric bilayered vesicles that completely encapsulate an aqueous volume with a membranous lipid bilayer composed primarily of cholesterol and non-ionic surfactants. These are similar to liposomes which can entrap both hydrophilic and hydrophobic drugs [3-4].

Niosomes were first addressed in the cosmetic industry by Vanlerbeghe et al. in 1972. According to Handjanivila et al., a combination of cholesterol and a single alkyl chain non-ionic and non-toxic surfactant formed vesicles when it was hydrated. Since then, a variety of non-ionic surfactants, including polyglycerol alkyl ethers, glucosyl

dialkyl ethers, crown ethers, polyoxyethylene alkyl ethers, ester-linked surfactants, steroid-linked surfactants, brij, and a number of spans and tweens, have been utilised to produce vesicles. Niosomes are the vesicles that result [4] and size vary from 10nm to 100nm[5-6].

Numerous mechanisms have suggested numerous ways for how niosomes might improve the transport of medicines through membranes. These include (i) Niosomes as transdermal drug delivery system reversible alteration of lipid organisation, which affect the stratum corneum's barrier function, (ii) increasing stratum corneum hydration by preventing transepidermal water loss, which causes the cellular structure of the stratum corneum to loosen, and (iii) niosome adsorption and/or fusion on the skin's surface, which creates a high thermodynamic activity. The binding of ligands on the niosomal membrane to particular receptors on the cell surfaces, which results in the direct transfer of the drug from the vesicles to the skin, may cause niosomes to adsorb onto the skin cell surfaces through the action of physical forces. On the other hand, total mixing of the niosomal contents with the cytoplasm can occur when niosomes fuse with the cell membrane. The entrapped niosomal material may potentially be released into the cell cytoplasm as a result of endocytosis of niosomes by skin cells and lysosomal breakdown [7-8].

Advantages [4-10]:

1. Similar to liposomes, entrap the solute.
2. Increases the stability of the drugs that is entrapped and is osmotically active and stable.
3. There are no additional requirements for handling or storing surfactants.
4. Take into consideration drug substances with a variety of solubilities.
5. Increase the oral bioavailability of drugs that are not well absorbed and can also increase drug penetration via the skin.
6. Can be administered orally, parenterally, or topically to deliver the drug to the site of action.
7. Niosomal surfactants are non-immunogenic, non-toxic, biodegradable, and biocompatible.
8. By delaying the clearance of drug molecules from the bloodstream, shielding them from the biological environment, and limiting their effects to target cells, niosomes enhance the therapeutic effectiveness of drug molecules.
9. They might increase how long the drug is trapped in circulation.
10. Can be utilised to transport drugs that are hydrophilic, lipophilic, and amphiphilic, as well as pharmaceuticals with a wide range of solubility.
11. Niosomes decrease the systemic toxicity of drugs including anti-infectives and anti-cancer medicines.

Disadvantages:

1. Physically unstable and it may form aggregation.
2. Entrapped drug leakage may occur.
3. Rarely, non-ionic surfactants interact with other components of the system and cause the formulation to become homogeneous or to precipitate.

Types of Niosomes [11-12]:

The classification of niosomes depends on several factors, including the number of bilayers (MLV, SUV), size (LUV, SUV), and manufacturing process (REV, DRV). The following is a description of the many

Niosome Types:

i) Multi lamellar vesicles (MLV) 1-5 um size.
ii) large uni-lamellar vesicles (LUV) 0.1- 1 µm size.
iii) small uni-lamellar vesicles (SUV) 25-500 nm size.

Multi Lamellar Vesicles (MLV): It comprises many bilayers that each individually enclose the aqueous lipid compartment. These vesicles have a diameter that ranges from 0.5 to 10 micrometres. The most common niosomes are multilamellar vesicles. It is simple to produce and mechanically stable when kept in storage for an extended period of time. These vesicles are suitable for use as lipophilic compound drug carriers.

Large Uni-Lamellar Vesicles (LUV): These niosomes feature a high aqueous/lipid compartment ratio, allowing for more bioactive molecules to be entrapped while using membrane lipids much more sparingly.

Small Uni-Lamellar Vesicles (SUV): The majority of these tiny unilamellar vesicles are made from multilamellar vesicles by sonication, French press extrusion, and electrostatic stabilisation, which is accomplished by adding dicetyl phosphate to CF-loaded, Span 60-based

niosomes with 5(6)-carboxyfluorescein (CF) loads.

Composition of Niosomes [13-15]

For preparing niosomes, the main components are non-ionic surfactant, cholesterol and other additives.

Non-Ionic Surfactant: Unlike liposomes, which are mostly made of phospholipids, niosomes are primarily made of non-ionic surfactants. Non-ionic surface-active molecules are amphiphilic molecules having a polar head and a non-polar tail. Since surfactants don't carry any charge, they are more stable, compatible, and safe than anionic, cationic, and amphoteric surfactants. Non-ionic surfactants have the important property of inhibiting p-glycoprotein, in which the immersion can enhance and targeting of anticancer medicines, such as Doxorubicin, Daunorubicin, Curcumin, and Morusin, steroids such as hydrocortisone, HIV protease inhibitors such as Ritonavir, and cardiovascular medicines such as aspirin. The HLB of the surfactant affects the efficiency of niosome entrapment. The length of the alkyl chain and the size of the vesicle both grow when the HLB score increases. For the production of niosomes, surfactants with HLB in the range of 14–17 are unacceptable. Span (span 20, 60, 40,80,85) and tween (tween 20,40,60,80) and brij (Brij 30,35,52,58,72,76) are generally used for the preparation of niosomes.

Type of Non-ionic surfactant	Examples
Fatty alcohol	Cetyl alcohol, Steryl alcohol, Cetosteryl alcohol, oleyl alcohol
Ethers	Brij, Decyl glucoside, Lauryl glucoside, Octyl glucoside, Triton X-100, Nonoxynol-9
Esters	Glyceryl laurate, polysorbates, spans
Block copolymers	Polaxamers

Table 1.2: Different types of Non-ionic surfactants [15].

Cholesterol: In the bilayer structure of niosomes, the hydrophilic head of a surfactant forms hydrogen bonds with cholesterol. The concentration of cholesterol in the niosome and how effectively it can enclose and sustain its loaded state have an impact on these physical and structural characteristics. Cholesterol influences the system's gel/liquid phase transition temperature and has an impact on membrane fluidity through interactions with nonionic surfactants (16). Due to its effect on niosome stability and rigidity, cholesterol is effective in preventing leakage and may change the efficiency of drug entrapment in niosomal formulations by altering the cholesterol content. The amount of cholesterol that must be added depends on the HLB value of the surfactants. The cholesterol concentration must be raised when the HLB value rises in order to offset the effect of the larger head groups on the critical packing parameter (CPP) [14].

Other Additives: Niosomes' capacity to change their structure and physicochemical characteristics by adding various additives is one of their advantages. As a result, since vesicle features rather than the physicochemical qualities of the drug play a more significant part in determining pharmacokinetics and the drug delivery process, both processes may be further enhanced. To impart desired properties, several additives may be added to the niosomal composition [16].

Factors Affecting the Formation of Niosomes

Selection of Surfactants and Additives: To make niosomes, a surfactant has to have a hydrophilic head and a hydrophobic tail. One, two, or perhaps one or more alkyl, perfluoroalkyl, or in certain situations, steroidal groups may make up the hydrophobic tail. The single-chain alkyl tail of ether-type surfactants makes them more hazardous than their dialkyl corresponding bodies. Since ester-linked surfactants are in vivo degraded by Esterases to triglycerides and fatty acids, they are chemically less stable than ether-type surfactants and less hazardous than the latter. For the creation of niosome, surfactants with alkyl chains ranging from C12 to C18 are appropriate. Surfactants from the Span series with an HLB number of 4 to 8 can generate

vesicles [16].

Drug: The interaction of the solute with surfactant head groups, which raises the charge and mutual repulsion of the surfactant bilayers, increases the vesicle size when the drug is trapped in niosomes. Some drugs get trapped in the lengthy PEG chains in polyoxyethylene glycol (PEG) coated vesicles, which lessens the tendency for them to expand in size. The degree of entrapment is influenced by the drug's hydrophilic-lipophilic balance [17].

Charge and Cholesterol Content: Cholesterol increases niosome hydrodynamic diameter and trapping efficiency. In general, cholesterol acts in two ways: on the one hand, it boosts the chain order of bilayers in the liquid state, and on the other, it lowers the chain order of bilayers in the gel state. The gel state changes into a liquid-ordered phase at high cholesterol concentrations. A decrease in the release rate of the material that was encapsulated and an increase in the stiffness of the resulting bilayers were caused by an increase in the cholesterol content of the bilayers. In a multilamellar vesicle structure, the presence of charge tends to increase the interlamellar distance between succeeding bilayers and results in a greater total entrapped volume.

Resistance to Osmatic Stress: When a hypertonic solution is introduced to a Niosomal suspension, the size of the Niosome reduces. In a hypotonic salt solution, where niosomes are kept, the drug is initially slowly released, resulting in swelling. The slower release might be due to vesicle fluid eluting being inhibited. A quicker releasing phase was later seen. The breakdown of the niosome's mechanical structure as a result of mechanical stress may be what leads to this quicker release phase [14-17].

Critical Packing Parameter: The critical packing parameter affects the shape of the vesicle during niosomal formation. The shape of nanostructures produced by the self-assembly of amphiphilic molecules may be anticipated based on the CPP of a surfactant. The following Equation may be used to define the critical packing parameter, which relies on the symmetry of the surfactant:

$$CPP = \frac{v}{l_c \times a_o}$$

Where, v = area of the hydrophilic head group,
lc= crucial hydrophobic group length, and
ao= hydrophobic group volume.

Small hydrophobic tail spherical micelles may develop if CPP ≤ 1/3, for instance, correlating to a bulky head group. Bilayer vesicles can form if 1/2 ≤ CPP ≤ 1 and non-spherical micelles can form if 1/3 ≤ CPP ≤ 1/2. When the surfactant is made up of a large hydrophilic tail and a short hydrophobic tail, inverted micelles develop if CPP ≥ 1. The self-assembled structure and its morphological transition in amphiphilic liquids may be realised, explained, and predicted using CPP.

Methods of Preparations [18-20]: By hydrating nonionic surfactants with hydration medium, niosomes are usually prepared. But there are so many methods to formulate the niosomes they are:

1. Transmembrane pH gradient method,
2. Thin Film Hydration technique,
3. Reversed-phase evaporation,
4. Ether injection Method,
5. Bubbling of nitrogen,
6. Sonication,
7. Enzymatic method,
8. Single-pass technique and
9. Microfluidization
10. Formation of Niosomes from proniosomes

Transmembrane Ph Gradient Method: This theory states that the inside of the niosome has an acidic pH, which is lower than the outside. The niosome membrane is crossed by the additional unionised basic drug, but once inside, it becomes ionised in an acidic medium and is unable to exit the niosome, increasing the effectiveness of entrapment for such medications. Surfactant and cholesterol were dissolved in chloroform, and under low pressure, these will evaporate and form a thin film. By vortex mixing, this film is hydrated with an acidic chemical solution (often citric acid), and the result is kept freeze-thawed to produce niosomes. The aqueous solution containing the drug is added to the niosomal suspension. Phosphate buffer is added to increase the PH, and the interior of the niosomes becomes more acidic than the exterior medium. This will make the unionised form of the drug pass the bilayers of niosomes,

and after the drug enters the niosomes, it ionises in an acidic medium and makes successful entrapment.

Thin Film Hydration Technique: Thin-film hydration is a common technique used for preparing niosomes. Cholesterol and surfactant are dissolved in organic solvents (Chloroform: Ethanol) in a round bottom flask (fig 1) and kept for rotary evaporator along with speed, temperature and pressure. The thin film will be formed on the walls of the flask, and this was hydrated with preheated buffer and again kept for rotary evaporator for stirring. After sometimes the vesicles will be formed.

Figure.1: Rotary Evaporator

Reversed Phase Evaporation: Surfactant and cholesterol are dissolved in organic solvent (ethanol, chloroform), and an aqueous solution containing the drug was added and sonicated with a temperature of 4°c – 5°c. Further, after adding phosphate buffer saline (PBS), keep for sonication resulting in the formation of gel and temperature is increased, and pressure is reduced to 40°c to evaporate the solvent. The PBS has added again and kept for the bath sonicator at 60°c for 10min, and niosomes were formed.

Ether Injection Method: Ether injection method is prepared by dissolving non-ionic surfactant and cholesterol in diethyl ether and taking the entire solution into a syringe. This solution is slowly introduced 1ml/min into a preheated buffer and kept for stirring until vesicles form. The gradual vaporisation of the solvent causes an ether gradient to extend towards the aqueous non-aqueous interface, which is likely what causes the development of bigger unilamellar vesicles. The creation of the bilayer structure may be due to the former. The vesicle's diameter ranges from 50 to 1000 nm, depending on the parameters used. This method's drawback is that it's challenging to get rid of the trace amounts of ether that are commonly present in the vesicles suspension.

Bubbling of Nitrogen: Organic solvents are not used in this procedure. Phosphate buffer saline (PBS), additives, and surfactants were put into a glass reactor with three necks. The reactor is set in a water bath to regulate the temperature. The thermometer is placed in the second neck, nitrogen gas enters the first neck, and water refluxes into the third neck. After 15 seconds of high-shear homogenizer mixing, these components are combined. Niosomes were produced when nitrogen gas was bubbled at 70 °C.

Sonication: The surfactant-cholesterol combination is initially distributed in the aqueous phase using this approach. Multilamellar vesicles (MLV) are created when this dispersion is probe sonicated for 10 min at 60°C. Unilamellar vesicles are created after additional ultrasonication of these MLVs, either by a probe sonicator or a bath sonicator.

Enzymatic Method: In this method, niosomes are generated from a mixed micellar solution via an enzymatic approach. Esterases degrade molecules such as polyoxyethylene and cholesterol, which when coupled with diacetyl phosphate and other lipids form multilamellar niosomes. The surfactants used in this process include polyoxyethylene cholesteryl sebacetate diacetate and polyoxyethylene stearyl derivatives.

Single-Pass Technique: It is a patented approach that involves the continuous extrusion of a lipid solution or suspension through a nozzle after passing through a porous device. It combines homogenization and high-pressure extrusion to provide niosomes a limited supply of sizes between 50 and 500 nm.

Microfluidization: To create unilamellar vesicles with a certain size distribution, a new approach has been developed. This approach is based on the submerged jet concept, in which two fluidized streams contact precisely designed microchannels inside an interaction chamber at extremely high speeds. It is designed such that the energy provided to the system stays in the region of niosomes

production when thin liquid sheets impact along a common front. The niosomes that are produced as a result are smaller, more consistent, and more repeatable [21].

Formation of Niosomes from Proniosomes: A water-soluble carrier, such as sorbitol or mannitol, is coated with surfactant when using the proniosome approach. A dry formulation is created as a result of the coating process. This substance is known as "Proniosomes" and has to be hydrated before usage. The inclusion of the aqueous phase results in the formation of the niosomes. This approach provides ease in dosing and storage while decreasing physical stability issues including the aggregation, leakage, and fusion problem. It also produces better outcomes than conventional niosomes.

Characterization of Niosomes [22-24]

There are many physicochemical methods for characterization of niosomes they are as follow:

1. Study of drug excipient-interaction
2. Size, Morphology and size distribution
3. Zeta potential
4. Optical microscopy
5. Drug Content
6. Entrapment efficiency
7. In-vitro drug release studies
8. Stability studies

Study of Drug Excipient-Interaction: Drug-excipient interactions can be determined using a variety of techniques. The most used methods are: FTIR, Differential scanning calorimetry (DSC) and X-ray diffraction technique (XRD).

These methods can identify the physicochemical states and interactions between drugs and excipients in nanotechnology and pharmaceuticals.

To evaluate the thermal and crystallinity properties of niosomes and excipients, DSC and XRD analyses were carried out. DSC often detects phase changes like the glass transition and crystallisation. The drug molecules' crystalline and amorphous states are identified using XRD methods.

To determine or evaluate drug-excipient interactions and search for any incompatibilities between the formulation's constituents, Fourier transform infrared spectroscopy (FTIR) was utilised. The incompatibility between the drug and the excipients was predicted by observing changes in the drug's distinctive peaks after mixing with the excipients. This method involves subjecting the sample to infrared radiation from an infrared source, which is then absorbed by the sample and deposits energy quanta into vibrational modes, stimulating vibrational movements. As a result, a molecule only absorbs radiation at frequencies that correspond to its molecular modes of vibration in the area of the electromagnetic spectrum between visible and short waves when it is subjected to radiation caused by the thermal emission of a hot source. Bands in the vibrational spectrum are created by these variations in vibrational motion, and each spectral band is identified by its frequency and amplitude.

Size, Morphology and Size Distribution: The size of niosomes and their morphology can be determined using a variety of methods, including light microscopy, photon correlation spectroscopy, electron microscopic analysis, SEM (scanning electron microscope) and TEM (transmission electron microscope), freeze-fracture replicators, light scattering, zeta sizer and meta sizer. Due to the differing measurement theories employed by the two, the transmission electron microscopy (TEM) approach yields lower particle sizes than the dynamic light scattering (DLS) method.

Zeta Potential: The charge on niosomes causes them to repel one another. Additionally, this electrostatic repulsion maintains them stable by avoiding fusion and aggregation. Zeta potential is used to measure the niosome charge. The zeta potential is measured using a zeta potential analyzer, master size, microelectrophoresis, pH-sensitive fluorophores, high-performance capillary electrophoresis, and DLS equipment. Henry's equation is used to determine zeta potential.

$$£ = \frac{\mu E \pi \eta}{\Sigma}$$

Where, £ = Zeta potential.
μE = Electrophoretic mobility
η = Viscosity of medium
Σ = Dielectric constant

Optical Microscopy: A drop of prepared sample was placed on glass slide and covered with a slip and these were viewed under optical microscope with magnification of 1200X. The obtained vesicles were taken by using digital SLR camera.

Drug Content: The drugs that are still in niosomes are identified by completely disrupting the vesicles with 50% n-propanol or 0.1% Triton X-100 or methanol and analysing the resulting solution using an appropriate assay method for the drug.

$$\%Drug\ content = \frac{Practical\ yield}{Theoritical\ yield} \times 100$$

Entrapment Efficiency: Unentrapped drugs are separated by dialysis, centrifugation, or gel filtration after niosomal dispersion has been prepared. This was kept for ultracentrifugation at 17000rpm for 40 minutes and temperature at 4°C. In this the supernatant layer was collected and analyzed by using UV spectrophotometer.

$$Entrapment\ Efficiency = \frac{Total\ drug - Unentrapped\ drug}{Total\ drug} \times 100$$

In-Vitro Drug Release Studies: The Invitro drug release studies were done by using Franz diffusion cells. In this it contains two chambers one is donor chamber and the other is receptor. The dialysis membrane was soaked before and placed in between the chambers. The niosomal suspension was kept in donor chamber and in receptor chamber phosphate buffer was kept with continuous stirring at 100rpm in magnetic stirrer and the sample was withdrawn at specific time interval and analyzed under UV spectrophotometer.

Stability Studies: The optimised batch was placed in airtight, sealed vials and kept there at various temperatures to test the stability of niosomes. Because drug leakage and decrease would result from formulation instability, surface characteristics and the proportion of drug maintained in niosomes and niosomes formed from proniosomes were chosen as metrics for assessing stability in terms of drug retention rate. The niosomes were sampled at regular intervals (0,1,2, and 3 months), observed for colour changes and surface properties, and tested for the percentage of drug retained after being hydrated to form niosomes and analysed using appropriate analytical methods (UV spectroscopy, HPLC methods, and so on) [25].

Applications of Niosomes [26-28]

To Increase Oral Bioavailability: As compared to the drug alone, it has been shown that the formulation of niosomes increased the oral bioavailability of acyclovir and griseofulvin. Similar to this, when provided as micellar solution together with the POE-24- cholesteryl ester in the bile duct of rats, poorly absorbed peptide and ergot alkaloid absorption can be boosted [24].

Anticancer Drug Delivery: In order to increase the therapeutic index of the anticancer drugs by localising the cytotoxic effects to target cells, methotrexate-loaded niosomes were initially used as a more reliable and cost-effective alternative drug delivery technology to liposomes. When vincristine was enclosed in niosomes, its anti-tumour action was also enhanced in mice having Ehrlich ascites and S-180 sarcoma. Additionally, in the two tumour types indicated above, Span 60 bleomycin niosomes enhanced bleomycin's anti-tumour effects. Doxorubicin's cytotoxic side effects were lessened when it was enclosed in C16G2 niosomes. The dosages chosen for usage in vivo did not cause hemolysis in vitro when doxorubicin copolymer-loaded niosomes were used. On the liver and spleen, C16G2 niosomes likewise had localised, long-lasting effects. In addition, niosomal delivery systems for 5-flurouracil based on Span 40 and Span 60 demonstrated a sustained and increased local concentration of the drugs in the liver and kidney of the rats when compared to the injectable drug solution. Recently, drug release has been effectively regulated using niosomes for the magnetic targeting of doxorubicin to a particular organ with no further toxicity.

Nsaids: The preparation of NSAID-loaded niosomes has been done by a number of different companies. Adverse reactions including mucosal irritation are possible with these drugs. Topically applied NSAID-loaded niosomes can considerably improve drugs penetration. Marianecci et al. developed ammonium glycyrrhizinate (AG) loaded niosomes with various surfactants and cholesterol concentrations to investigate the potential use of niosomes

for anti-inflammatory drug delivery. Drug entrapment efficacy, anisotropy, cytotoxicity, skin tolerability, and other parameters were explored for characterization. The AG-loaded niosomes demonstrated great skin tolerability, non toxin, and the capability to ameliorate anti-inflammatory exertion in mice. Additionally, when applied to chemically produced human skin erythema, the anti-inflammatory effect of the medication supplied through niosomes was shown to be enhanced.

Antiviral Drugs: The capacity of niosomes to distribute different antiviral drugs has also been established. Zidovudine, the first anti-HIV drug licensed for clinical use, was developed by Ruckman and Sankar. They then entrapped niosomes and evaluated the effectiveness of their entrapment as well as the sustainability of release. The ratios of Tween, Span, and cholesterol were combined to create niosomes. Tween 80 niosomes caught a large amount of zidovudine, and the addition of diacetyl phosphate extended the duration of drug release. Compared to niosomes maintained at 4°C for 90 days, the drug leakage from Tween 80 formulations held at room temperature was substantial. Further evidence that Tween 80 formulations containing diacetyl phosphate were eliminated from circulation after five hours came from the results of a pharmacokinetic research conducted on rabbits.

Leishmaniasis: Drugs that target the niosome can be utilised to treat illnesses when the reticuloendothelial system's organ is the site of the infecting organism. A parasite infects the liver and spleen cells to cause leishmaniasis. Antimonials, which are routinely prescribed medications and are related to arsenic, harm the heart, liver, and kidney at high amounts. After administering sodium stibogluconate in the free, liposomal, and niosomal forms, the quantities of antimony in the mouse's liver and serum were measured. Both vesicular formulations resulted in high liver and low serum levels. The ability of niosomal sodium stibogluconate to treat experimental murine visceral leishmaniasis to be more effective than free drug appears to be contingent on maintaining high drug levels in the infected reticuloendothelial system.

Cosmetics: The cosmetic products developed by L'Oreal were the source of the first report of non-ionic surfactant vesicles. In the 1970s and 1980s, L'Oréal invented and patent niosomes. Lancôme debuted "Niosome," the first product, in 1987. The benefits of employing niosomes in cosmetic and skin care products include their capacity to improve the bioavailability of chemicals that are difficult to absorb as well as skin penetration.

Peptide Drug Delivery: It has long been difficult to avoid the enzymes that would break down peptides used in drug administration. Investigations are being done on the potential use of niosomes to successfully shield peptides from peptide breakdown in the gut. An in vitro study utilising a vasopressin derivative trapped in niosomes indicated that drug entrapment significantly increased peptide stability [29].

Antibiotics: Antibiotic and anti-inflammatory drug delivery can be accomplished using niosomal carriers. These carriers have been employed often to increase drugs retention in the skin and to improve ineffective skin penetration. Rifampicin, a niosomal delivery system-encapsulated wide range antibiotic, was developed by Begum and her colleagues. This work demonstrated that the niosomal formulation of rifampicin is capable of providing constant and sustained release of the medication. They studied the activity of this system in in vitro environments.

Conclusions: When compared to other carriers, the use of niosome as a drug carrier, particularly for antifungal drugs, produces better results. The capacity to encapsulate both hydrophilic and hydrophobic drugs, as well as their prolonged stability in circulation, are all major characteristics of niosomes. They also considerably improve drug penetration through the skin. They may make suitable candidates for the treatment of fungi-related disorders since the cost of the raw ingredients (mainly surfactants) is lower than that of liposomes. Niosomes are considered as successful carrier drug delivery system for topical drug delivery [30].

References

1. Makeshwar KB, Wasankar SR. Niosome (2013) a novel drug delivery system. Asian journal of pharmaceutical research. 3: 16-20.

2. Ge X, Wei M, He S, Yuan WE (2019) Advances of Non-Ionic Surfactant Vesicles (Niosomes) and Their Application in Drug Delivery. Pharmaceutics 11: 55.
3. Parekh F, Patel B, Vyas K, Patani P (2022) Recent Advances and Scopes In Niosomes. Journal of Pharmaceutical Negative Results 12: 2093-2102.
4. Kazi, K M, Mandal A S, Biswas N, Guha A, Chatterjee S, et al. (2010) Niosome: A future of targeted drug delivery systems. Journal of advanced pharmaceutical technology & research 1: (374–380).
5. Momekova D B, Gugleva VE, Petrov PD (2021) Nanoarchitectonics of Multifunctional Niosomes for Advanced Drug Delivery. ACS Omega 6: 33265-33273.
6. Tangri P, Khurana S Niosomes (2011) Formulation and evaluation. International Journal 2229-7499.
7. Gharbavi M, Amani J, Kheiri-Manjili H, Danafar H, Sharafi A. Niosome (2018) a promising nanocarrier for natural drug delivery through blood-brain barrier. Advances in Pharmacological and Pharmaceutical Sciences https://pubmed.ncbi.nlm.nih.gov/30651728/.
8. Thabet Y, Elsabahy M, Eissa NG (2022) Methods for preparation of niosomes: A focus on thin-film hydration method. Methods 199: 9-15.
9. Khoee S, Yaghoobian M Niosomes (2017) a novel approach in modern drug delivery systems. Nanostructures for Drug Delivery 207-237.
10. Shirsand SB, Keshavshetti GG (2019) Recent advances in niosomal drug delivery—A review. Res. J. Life Sci. Bioinform. Pharm. Chem. Sci 3: 514-531.
11. Sezgin-Bayindir Z, Yuksel N (2012) Investigation of formulation variables and excipient interaction on the production of niosomes. Aaps Pharmscitech. 13: 826-835.
12. Bhardwaj P, Tripathi P, Gupta R, Pandey S (2020) Niosomes: A review on niosomal research in the last decade. Journal of Drug Delivery Science and Technology 56: 101581.
13. Rajera R, Nagpal K, Singh SK, Mishra DN (2011) Niosomes: a controlled and novel drug delivery system. Biological and Pharmaceutical Bulletin 34: 945-953.
14. Sharma D, Aara A, Aate J (2018) Niosomes as Novel Drug Delivery System: Review Article. Pharma Tutor 6: 58-65.
15. Abdelkader H, Alani AW, Alany RG (2014) Recent advances in non-ionic surfactant vesicles (niosomes): self-assembly, fabrication, characterization, drug delivery applications and limitations. Drug delivery 21: 87-100.
16. Ag Seleci D, Seleci M, Walter JG, Stahl F, Scheper T (2016) Niosomes as nanoparticular drug carriers: fundamentals and recent applications. Journal of nanomaterials https://doi.org/10.1155/2016/7372306.
17. Nasir A, Harikumar SL, Amanpreet K (2012) Niosomes: An excellent tool for drug delivery. international journal of research in pharmacy and chemistry 2: 479-487.
18. Atif M, Singh SP, Kumar A (2018) NIOSOMES: A NOVEL FORMULATION FOR ANTI-AGEING COSMECEUTICALS. European Journal of Biomedical 5: 370-375.
19. Osanloo M, Assadpour S, Mehravaran A, Abastabar M, Akhtari J (2018) Niosome-loaded antifungal drugs as an effective nanocarrier system: A mini review. Current medical mycology 4: 31-36.
20. Rathod HJ, Mehta DP (2017) A review on pharmaceutical gel. International Journal of Pharmaceutical Sciences 1: 33-47.
21. Soni A, Chaudhary A, Singla S, Goyal S (2018) Review on: Novel Approach in Pharmaceutical Gel. Journal of Current Pharma Research 9: 2576-2588.
22. Abdellatif MM, Khalil IA, Khalil MA (2017) Sertaconazole nitrate loaded nanovesicular systems for targeting skin fungal infection: in-vitro, ex-vivo and in-vivo evaluation. International journal of pharmaceutics 527:1-11.
23. Smith JD, Clinard VB () Natural products for the management of type 2 diabetes mellitus and comorbid conditions. Journal of the American Pharmacists Association. 54: e304-321.
24. Mishra S, Gupta RA (2022) Formulation and Evaluation of Niosomal Gel of Antifungal Luliconazole, Journal of Drug Delivery and Therapeutics 12: 47-54.
25. Menna M Abdellatif, Islam A Khalil, Yara E Elakkad, Hesham A Eliwa, Tamer M Samir Asmaa K Al-Mokaddem (2023) Formulation and Characterization of Sertaconazole Nitrate Mucoadhesive Liposomes for Vaginal Candidiasis, International Journal of Nanomedicine 4079-4090.
26. Shailaja D, Latha K, Manasa D, Shirisha A, Padmavathi R, et al. (2021) Formulation and evaluation of

proniosome loaded sertaconazole nitrate for topical application. International Journal of Life Science Research Archive 01:023–037.
27. Mohite M, Kumbhar T (2019) Preparation and evaluation of ketoconazole niosomal gel drug delivery system by ultrasonication method. World Journal of Pharmaceutical Research 8: 1303-1318.
28. Kumar Ashish, Dua J S (2018) Formulation and Evaluation of Itraconazole Niosomal Gel,Asian Journal of Pharmaceutical research and Development 6: 76-80
29. Kaur Paninder, Dua J S, Prasad D N (2018) Formulation and Evaluation of Ketoconazole Niosomal Gel, Asian Journal of Pharmaceutical research and Development 6: 71-75.
30. Veldurthi Ravalika, Abbaraju Krishna Sailaja (2017) Formulation and Evaluation of Etoricoxib Niosomes by Thin Film Hydration Technique and Ether Injection Method. Nano Biomed. Eng 9: 242-248.