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Niosome A Novel Drug Delivery System: A Review

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ABSTRACT:

Niosomes are microscopic vesicular carriers formed by self-assembly of non-ionic surfactants in the presence of cholesterol. They are considered a promising novel drug delivery system because they improve the therapeutic effectiveness of drugs while reducing adverse effects. Niosomes can encapsulate both hydrophilic and lipophilic drugs, making them suitable for a wide range of pharmaceutical applications. They enhance drug stability, improve bioavailability, provide controlled and targeted drug release, and protect drugs from enzymatic degradation. Due to their biodegradable, biocompatible, non-toxic, and non-immunogenic nature, niosomes have gained significant attention in pharmaceutical research. They are widely used in oral, topical, transdermal, ophthalmic, and parenteral drug delivery systems. Various preparation methods, including thin-film hydration, reverse-phase evaporation, ether injection, and sonication, are employed to formulate niosomes depending on the desired characteristics. The performance of niosomes is evaluated using parameters such as vesicle size, entrapment efficiency, zeta potential, morphology, and in vitro drug release. Despite advantages such as improved stability and cost-effectiveness compared to liposomes, challenges including aggregation, drug leakage, and storage stability remain. Overall, niosomes represent an efficient and versatile carrier system with great potential for targeted therapy and improved patient compliance, making them an important area of research in modern pharmaceutical drug delivery.

Keywords: Niosomes, Compositions, Preparation Methods, Factors affecting, Characterizations, and Applications.

1.INTRODUCTION

The niosome is composed of non-ionic surfactants containing cholesterol and a small amount of ionic surfactants, such as diacetyl phosphate, which is used for stability. L'Oréal Company created and marketed the first non-ionic surfactant product, which was used for cosmetic purposes. Because of their multi-environmental structure, niosomes can deliver a variety of drugs to specific sites. The goal of targeting drug delivery systems is to deliver the drug in the body in such a way that it demonstrates its action to the targeted and desired site to achieve the therapeutic response, i.e. wherever its action is required by limiting undesired interaction to non-targeted tissues.

Liposomes, niosomes, transferosomes, pharmacosomes, and ethosomes are examples of vesicular systems that can be used to improved drug delivery. Among these various carriers, niosomes are highly efficient drug delivery systems.

Niosomes are a vesicular, novel drug delivery system that can be used for long-term, controlled, and targeted medication delivery with high stability. Niosomes are a novel drug delivery system in entraps hydrophilic drugs in the core cavity and hydrophobic drugs in the non-polar region of the bilayer, allowing both hydrophilic and hydrophobic drugs to be incorporated into the niosome.

Niosome can be administered via a variety of routes, including oral, parenteral, topical, and ocular administration. The medication is encapsulated in a vesicle in the niosome drug delivery system. The vesicle is made up of a bilayer of non-ionic surfactants, thus the name niosomes. Niosomes are one of the most effective carriers.

Niosomes are structurally similar to liposomes and have the same drug delivery potential, but their high chemical stability and economy make them superior to liposomes. Both are made up of the bilayer, which is composed of a non-ionic surfactant.

. Niosomes are microscopic lamellar structures with sizes ranging from 10 to 1000 nm that are made up of biodegradable, non-immunogenic, and biocompatible surfactants.

Niosomes are one of the techniques used to create a controlled release system. Niosomes have a multilamellar or unilamellar structure that is formed by combining a non-ionic surfactant, cholesterol, and diethyl ether, followed by hydration aqueous media. Niosomes outperform liposomes in terms of surfactant chemical stability, as oppose phospholipids, which are easily hydrolysed due to the ester bond, and cost effectiveness.[1,2]

1.1 ADVANTAGES

- Side effects are reduced, and the activity lasts as long as possible.
- Side When compared to alternative delivery systems, patient compliance higher.
- The amount of medicine required to provide the desired effect is extremely little.
- Bilayer protects the active component or constituent in the preparation.
- from numerous influences both inside and outside the body.
- As a depot formulation, the drug is released slowly and steadily.
- First-pass metabolism and gastrointestinal degradation are not a problem for this drug.
- Even in emulsion form, they have a stable structure.
- Niosomes can be used orally, topically, or intravenously.
- Niosomes can hold a wide range of drug moieties, including hydrophilic, lipophilic, and amphiphilic medicines.[3]
- The drug can be released in a controlled and continuous manner.
- No special conditions required for handling and storage of surfactants.
- Drug defence against enzyme metabolism.
- They can improve drug penetration through the skin.

1.2 DISADVANTAGES:

- The procedure takes a long time.
- Due to the limited shelf life
- Cohesion
- Compilation
- Entrapped drug leakage
- Drugs that have been encapsulated are hydrolysed
- Physical instability
- Aggregation
- Fusion
- Leaking of entrapped drug

1.3 SIGNIFICANT CHARACTERISTICS OF NIOSOMES:

- Solutes can be trapped by niosomes.
- Niosomes are stable and osmotically active.
- Niosomes can be created to fit a variety of conditions thanks to their structural flexibility (composition, fluidity, and size).
- Niosomes can enhance the functionality of drug molecules.
- Improved accessibility to the specific spot simply by shielding the medicine from the biological environment.
- Niosomes make the medicine that is entrapped more stable.
- The infra-structure of niosomes is mostly made up between hydrophilic and hydrophobic molecules together, allowing the drug atoms a broad spectrum of dissolvability.
- Niosomes function as a medication storage facility in the body because they release the medication in an orderly fashion using their bilayer, which supports the arrival of the encased medication.[4]

1.4 TYPES OF NIOSOMES:

The various niosome kinds can be categorised.as follows: (Figure 1).

1. Multilamellar vesicles (MLV)

2. Big unilamellar vesicles (LUV)

3. Small unilamellar vesicles (SUV)

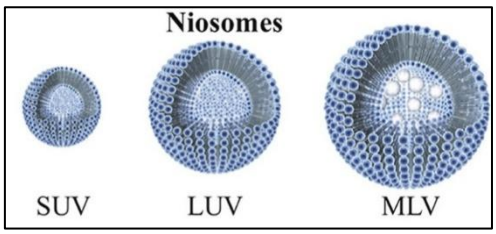


Figure 1: Types of Niosome

1) Multilamellar vesicles (MLV):

Niosomes are most frequently seen in multilamellar vesicles. The vesicles have a diameter that varies between 0.5 and 10 m. The vesicles are easily prepared, and after being stored for a while, they remain mechanically stable. In most cases, each aqueous lipid component is surrounded by a number of bilayers. As medication carriers for lipophilic substances, they are called multilamellar vesicles ideally suited.

2) Big unilamellar vesicles (LUV):

Large unilamellar type niosomes have a high aqueous/liquid compartment ratio, allowing for more bioactive material to be confined in a given volume while using a fraction of the membrane lipids. Large unilamellar vesicles range from 100 to 3000 nm in length in size.

3) Small unilamellar vesicles (SUV):

By using the sonication process, small unilamellar vesicles are often created from multilamellar vesicles. The size of the small unilamellar vesicles has been estimated to be between 10 and 100 nm.

2. STRUCTURE OF NIOSOMES:

The spherical niosomes in (Figure 2) contain the miniature lamellar (single or many lamellae) structures. Non-ionic the bilayer is produced using surfactants, either with or without cholesterol, and a charge inducer. Niosomes are created by combining various surfactant types in different molar ratios and combinations. Surfactants come in a variety of forms, including sorbitan fatty acid esters, fatty acid esters made by polyoxyethylene, alkyl ethers, and alkyl glyceryl ethers Cholesterol addition keeps the bilayer firm, resulting in fewer leaky niosomes. Charge inducers, on the other hand, give the vesicles a charge and increase their size, enhancing the efficiency of drug entrapment. According to the size of their vesicles: small unilamellar vesicles (0.025-0.05 mm), multilamellar vesicles (>0.05 mm), and the enormous unilamellar vesicles (>0.10 mm).[4,5]

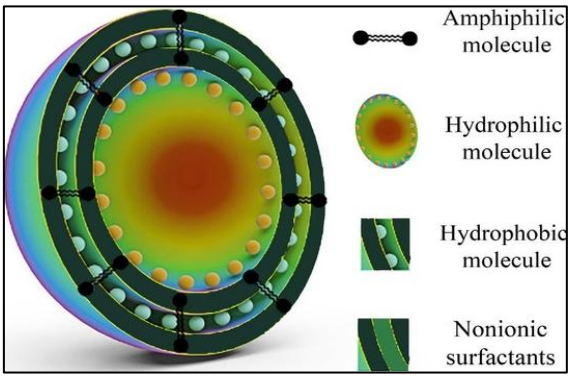


Figure 2: Structure of Niosome

2.1 NIOSOME COMPOSITION:[6,7]

The following essential ingredients are utilised to create niosomes:

1. Non-ionic surfactants

2. Cholesterol

3. Charge inducer

4. Moderate Hydration

1. Non-ionic surfactants:

The surface-active component serves as the main ingredient in the composition of the noisome. They have a polar head and a non-polar tail, making them amphiphilic in nature. Because they don't carry any charge, these substances are more stable, compatible, and non-toxic than other surfactants like anionic, cationic, and amphoteric surfactants.

2. Cholesterol:

The primary use of cholesterol, a waxy steroid derivative found in cell membranes, is in the synthesis of niosomes. By adding cholesterol to the niosomes' bilayer structure cellular membrane permeability is reduced, frequently increasing the trapping efficiency of the niosomes. Cholesterol is typically used as a direction or adjustment to non-ionic surfactants to provide the rigidity of the niosomal bilayer and the proper. Because cholesterol can stop the niosomal system from going from a gel to a liquid phase, niosomes are less likely to leak.

3. Charge inducers:

To boost niosome stability by electrostatic repulsion and prevent Charge-inducing substances are coalescence. Added to the mixture. Phosphatidic acid and diacetyl phosphate (DCP) are the negatively charged substances that are used the most frequently. The positively charged inducers STR and stearyl pyridinium chloride are examples of stearyl amines. are both used in niosomal preparations.

4. Medium for hydration:

The hydrating agents employed most frequently in the creation of niosomes is phosphate buffer. These phosphate buffers are used at various pH values. The actual pH of the hydration media is impacted by the solubility of the medication being encapsulated.

Table 1: Types of surfactants used in niosome preparation and their example.

Non-ionic surfactants	Examples of surfactant
Alkyl esters: (i) Sorbitan fatty acid esters (Spans) (ii) Polyoxyethylene Sorbitan fatty acid esters (Tweens)	Span 20, Span 40, Span 60, Span 80, Span 65, Span 85 Tween 20, Tween 40, Tween 60, Tween 80, Tween 65, Tween 85
Alkyl ethers: (i) Alkyl glycerol ethers (ii) Polyoxyethylene glycol alkyl ethers (Brij)	Hexadecyl diglycerol ether Brij30, Brij52, Brij72, Brij76
Crown ethers	Bola
Alkyl amides: 1. Glycosides 2. Alkyl polyglycolide	C-glycoside derivative surfactant Octyl-decyl polyglucoside
Fatty alcohols or fatty acids: 1. Fatty alcohols 2. Fatty acids	Stearyl alcohol, acetyl alcohol, myristyl alcohol Stearic acid, Palmitic acid, myristic acid.
Block copolymer: (i) Pluronic	Pluronic L64, Pluronic 105.
Charged molecule: Negative charge Positive charge	Diacetyl phosphate, phosphatidic acid, lipoamino acid, dihexadecyl phosphate Stearyl amine, stearyl pyridinium chloride.

2.2 LIPOSOME AND NIOSOME DIFFERENCES

Table: 2

Not contain Cholesterol	Cholesterol present
Phospholipid unstable	Cholesterol stable
Phospholipid may have neutral charged	Non-ionic surfactant uncharged

Liposomes	Niosomes
Highly expensive	Less expensive
Phospholipids can degrade by oxidation.	Surfactants that are non-ionic are resistant to oxidative deterioration.
Need for a distinct method for purification, storage, and handling of phospholipid	No unique method is needed
Comparatively more toxic	Less toxic
Size range 10-3000 nm	Size range 10-100 nm

3. METHOD OF PREPARATION:[8,9]

1. Thin film hydration technique (Hand shaking method)

2. The micro fluidisation method

3. Reverse Phase Evaporation Method (REV)

4. Ether Injection Method

5. Trans-membrane pH-gradient (inside acidic)

6. The Sonication method

7. Multiple extrusion method

8. Formation of niosomes from proniosomes

1) THIN FILM HYDRATION TECHNIQUE (HAND SHAKING METHOD):

The mixture of vesicles forming ingredients like surfactant and cholesterol are dissolved in a volatile organic solvent (diethyl either, chloroform or methanol) in a round bottom flask. The organic solvent is removed at room temperature (20°C) using rotary evaporator leaving a thin layer of solid mixture deposited on the wall of the flask. The dried surfactant film can be rehydrated with aqueous phase at 0860°C with gentle agitation. This process forms typical multilamellar niosomes.

Preparation steps:

- Surfactant + cholesterol + solvent
- Remove organic solvent at Room temperature
- Thin layer formed on the Walls of flask
- Film can be rehydrated to form multilamellar Niosomes

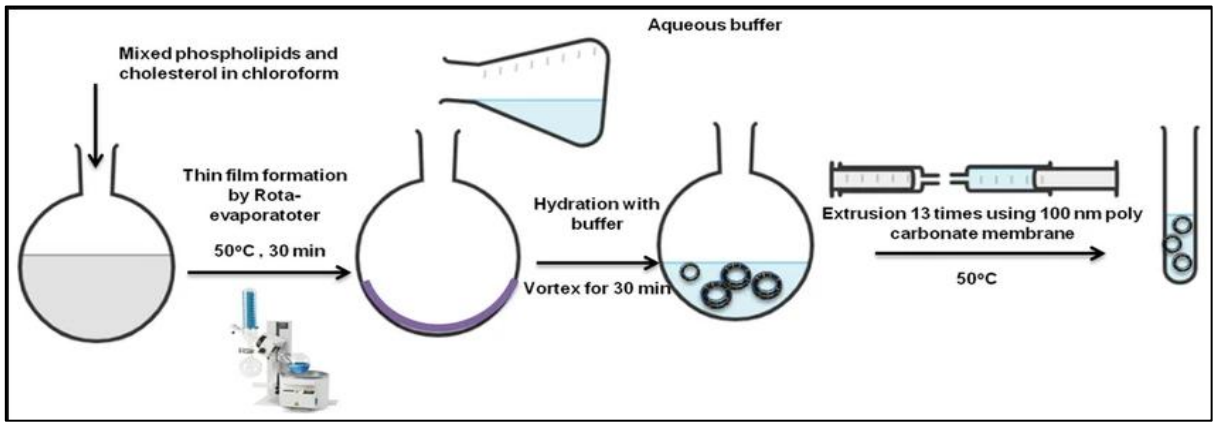


Figure 3: Thin film hydration technique (Hand shaking method)

2) THE MICRO FLUIDISATION METHOD:

The micro-fluidization strategy can be applicable to produce unilamellar vesicles with a certain size distribution, as demonstrated in figure 4. It is based on the submerged jet principle, where two fluidized streams contact at extremely high speeds (100 ml/min) in narrowly defined microchannels inside the interaction chamber. The energy given to the system stays in the area where niosomes are produced because the thin liquid sheet impingement is arranged along a single front. Niosomes made using this method are more homogeneous, smaller, and repeatable.

Preparation steps

- Inside interaction chamber two ultra-high-speed jet Present
- Impingement of thin layer of Liquid in micro channels
- Yield of uniform Niosome

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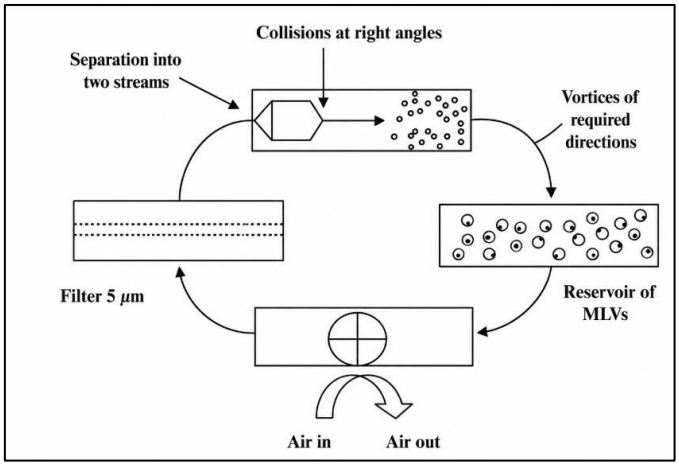


FIGURE:4 MICRO FLUIDISED METHOD

3. REVERSE PHASE EVAPOURATION TECHNIQUE(REV):

Cholesterol and surfactant are dissolved in a mixture of ether and chloroform. An aqueous phase containing drug is added to this and the resulting two phases are sonicated at 485°C. The clear gel formed is further sonicated after the addition of a small amount of phosphate buffered saline (PBS). The organic phase is removed at 40°C under low pressure. The resulting viscous noisome suspension is diluted with PBS and heated on a water bath at 60°C for 10 min to yield niosomes.

Preparation steps

- Cholesterol + surfactant dissolved in ether + chloroform
- Sonicated at 5oc and again sonicated after adding PBS
- Drug in aqueous phase is added to above mixture
- Viscous niosomes suspension is diluted with PBS
- Organic phase is removed at 40oC at low pressure
- Heated on a water bath for 60oC for 10 mints to yield niosomes

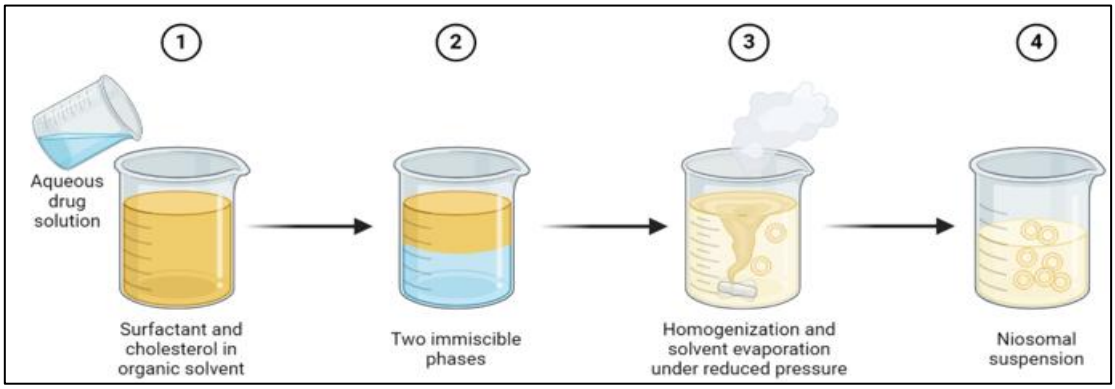


Figure 5: Reverse Phase Evaporation Method (REV)

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4. 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 60°C. The surfactant mixture in ether is injected through 148gauge 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.

PREPARATION STEPS

- Surfactant is dissolved in diethyl ether.
- Then injected in warm water maintained at 60oC through a 14 gauze needle.
- Ether is vaporized to form single layered niosomes.

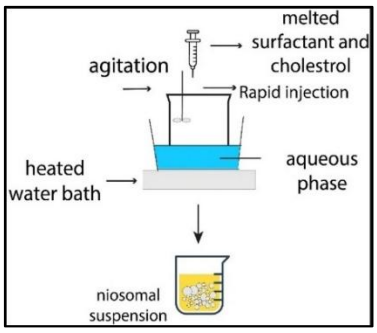


Figure 6: Ether injection method

5. TRANS-MEMBRANE PH GRADIENT (INSIDE ACIDIC):

This procedure involves mixing/blending cholesterol and surfactant in a round-bottomed flask before dissolving it in chloroform. As the chloroform evaporates at a low pressure, a thin film is created on the flask's wall. The film is hydrated using vortex mixing with 300mM citric acid (pH 4.0). The previously described niosomal suspension is combined with an aqueous solution that has 10 mg/ml of the medicine before being vortexed. The sample's pH is decreased to 7.0–7.2 by adding 1M disodium phosphate, and the mixture is then heated at 60°C for 10 minutes. This technique results in multilamellar vesicles.

PREPARATION STEPS

- Surfactant + cholesterol in chloroform
- Solvent is evaporated under reduced pressure
- Thin film is deposited on the walls of RBF
- Hydrated with citric acid by vortex mixing
- cycles of freezing and thawing then sonication
- Addition of aqueous drug solution and vertexing
- pH raised to 7.087.2 by 1M disodium phosphate
- RBF as bubbling unit with three necks in water bath
- Reflux, thermometer and nitrogen supply by three necks

- Cholesterol + surfactant dispersed in buffer pH 7.4 at 70ºC.
- Above dispersion is homogenized for 15 sec and then bubbled with nitrogen gas at 70ºC.
- To get niosomes.

7. SONICATION METHOD

A typical method of production of the vesicles is by sonication of solution as described by Cable. In this method an aliquot of drug solution in buffer is added to the surfactant/cholesterol mixture in a 108ml glass vial. The mixture is probe sonicated at 60°C for 3 minutes using a sonicator with a titanium probe to yield niosomes.

PRAPARATION STEPS

- Drug in buffer + surfactant/cholesterol in 10 ml
- Above mixture is sonicated for 3 mints at 60oC using titanium probe yielding niosomes

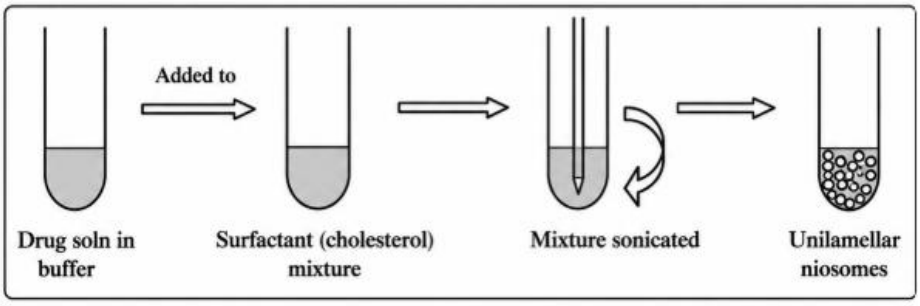


FIGURE:7 SONICATION METHOD

8) MEMBRANE EXTRUSION METHOD:

This process involves mixing diacetyl phosphate, cholesterol, and surfactant with chloroform. Then a thin film is created by evaporating this chloroform mixture. Polycarbonate membranes are hydrated using an aqueous solution. Extrusion of the solution and the resulting suspension occurs through this membrane, which has eight channels. This approach is also used to determine the required size of the niosomes,

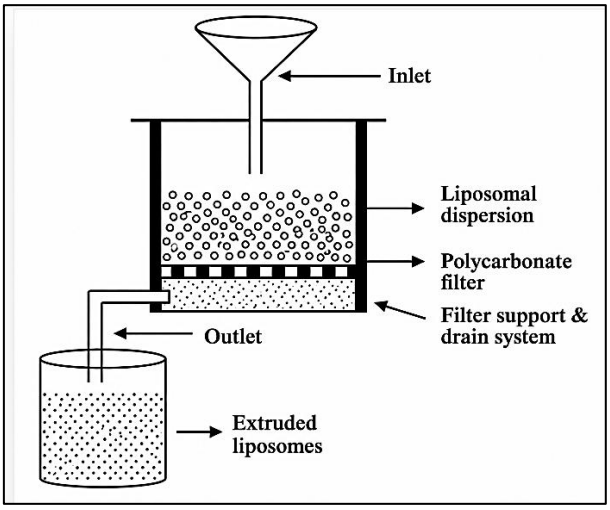


FIGURE 8: MEMBRANE EXTRUSION METHOD

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9) FORMATION OF NIOSOMES FROM PRONIOSOMES:

Niosomes are formed by adding aqueous phase with medication to proniosomes with brief agitation at a temperature higher than the surfactant's typical transition phase temperature. where is the temperature and Tm is the average phase transition temperature A.I. Blazek-Walsh et al. have documented the creation of niosomes from proniosomes based on malt dextrin. Niosomes can be quickly reconstituted with this formulation, and the amount of leftover/remaining carrier is small. A free-flowing formulation powder was created by drying the malt dextrin and surfactant slurry, which could be rehydrated by adding warm water.

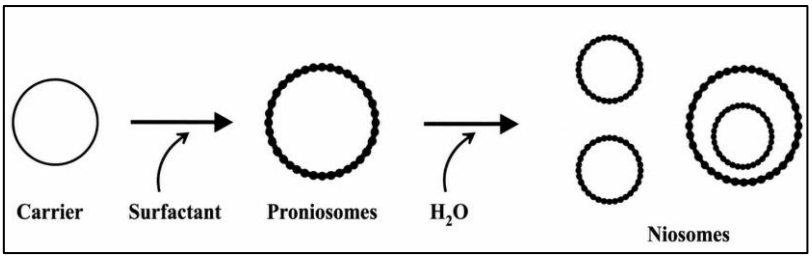


Figure 9: formation of proniosomes

4.EVALUATION OF NIOSOMES:[11,12,13]

1.Angle of repose measurement:

Using a funnel approach, the angle of repose of dried niosome powder was determined. A funnel with a 13mm output aperture that was positioned such that it was 5 cm above a flat, dark surface received niosome powder. After the powder falls down from the funnel to form a cone on the surface, the height of the cone and the diameter of its base were measured to determine the angle of repose.

2. Optical Microscopy:

After appropriate dilution, the niosomes were placed on glass slides and observed morphologically using a microscope (Medilux-207RII, Knowlagent, Ambala, India) at a magnification of 1200X. Using a digital SLR camera, the photomicrograph of the preparation was also taken under the microscope.

3.Vesicle size and shape:

The spherical shape of niosomal vesicles is assumed, and their mean diameter can be determined using the laser light scattering method. Electron microscopy, molecular sieve chromatography, ultracentrifugation, photon microscopy, optical microscopy, and freeze fracture electron microscopy can also be used to determine the diameter of these vesicles. The vesicle diameter of frozen thawed niosomes increases, which may lead to vesicle fusion during the cycle.

4.Number of lamellae:

Using an electron microscope, NMR spectroscopy, or X-ray scattering, the number of lamellae in niosomes can be determined.

5.Membrane rigidity:

The niosomes membrane rigidity is measured using the mobility of the fluorescence probe as a function of temperature.

6.Bilayer Formation:

Under light polarisation microscopy, the formation of X-crosses characterises the assembly of non-ionic surfactants to form bilayer vesicles.

7.Stability Study:

The stability of niosomes can be assessed by measuring mean vesicle size, size distribution, and entrapment efficiency over several months of niosomal suspension storage at various temperatures. During storage, niosomes are sampled at regular intervals and the percentage of drug retained in the niosomes is determined using UV spectroscopy or HPLC methods.

8.Vesicle charge:

The surface charge of niosomes plays an important role in their stability; charged niosomes are generally more stable than uncharged vesicles. It is calculated using the electrophoresis method or a zeta sizer.

9.Entrapment efficiency

Entrapment efficiency of the niosomal dispersion in can be done by separating the unentrapped drug by dialysis centrifugation or gel filtration as described above and the drug remained entrapped in niosomes is determined by complete vesicle disruption using 50% n8propanol or 0.1% Triton X8100 and analysing the resultant solution by appropriate assay method for the drug. Were,

percentage entrapment =total drug-diffused drug x100

10. osmotic shock

The change in the vesicle size can be determined by osmotic studies. Niosomes formulations are incubated with hypotonic, isotonic, hypertonic solutions for 3 hours. Then the changes in the size of vesicles in the formulations are viewed under optical microscopy.

5. FACTORS AFFECTING NIOSOME FORMATION:[14,15]

- **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. The increase in vesicle size is due to the enhancement of charge and mutual repulsion between surfactant bilayers. The degree of entrapment is also affected by the drug's hydrophilic-lipophilic balance.

- **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. The mechanical loosening of the vesicle structure under osmotic stress causes the release to be faster.

- **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. It also influences surfactant assembly into vesicles. The volume of the hydration medium and the duration of the lipid film influence vesicle structure and yield.

- **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. It reduces the membrane's flexibility and, as a result, the drug's permeation across it. The amount of cholesterol used is determined by the surfactant's HLB value.

- **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.

- **Nature of encapsulated Drug**:

The nature of the drug being encapsulated influences niosomal formulation. The interaction of the surfactant head groups causes drug entrapment in vesicles and a charge increase. The formation of charge causes mutual repulsion of the surfactant bilayer, increasing vesicle size. The drug's HLB has a similar effect on the degree of entrapment.

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. Cholesterol increases the rigidity of the membrane, which reduces drug leakage.

- **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 phase transition temperature (TC) of the surfactant also influences entrapment efficiency; for example, span 60 with a higher TC provides better entrapment.

6. APPLICATION OF NIOSOMES[16,17,18]

1) Targeting of bioactive agents:

a) To the reticulo-endothelial system (RES):

The RES cells accept the vesicles preferentially. It is employable to treat liver parasite infestations as well as animal tumours that are known to metastasis to the liver and spleen.

b) To organs other than RES:

It has been suggested that the carrier system employs antibodies to go to a specific location in the body. Immunoglobulin makes it simple to target the drug's delivery system.

2) For the treatment of Leishmaniasis:

The parasite invades the liver and cells to cause leishmaniasis. Most people prefer antimonial over other medications. Two doses administered on succeeding days exhibited an additive effect on the sodium stibogluconate efficacy of the niosomal formulation, according to mouse antimony research. As drug-loaded liposomes, niosomes are also efficacious in experimental leishmaniasis.

3) Tumour targeting:

Chemotherapy is only effective if a considerable amount of an anticancer agent is present at the tumour site. This reduces the drug's concentration in other tissue compartments of the body, which lessens the negative effects. Numerous research teams have examined niosomes for improved transport of anticancer drugs to local lymphatics. To produce cytarabine hydrochloride niosomes with smaller vesicles, researchers used a lipid hydration approach without dicetyl phosphate. The vesicles that were produced size between 600 and 1000nm.The formulation with Span 60 produced the slowest rate of release out of the four surfactants chosen (Tween 20, Tween 80, Span 60, Span 80). An initial burst release that lasted for 2–6 hours was followed by a steady release that continued for at least 16 hours.

4) For the treatment of AIDS:

Human immunodeficiency virus (HIV), which results in a severely compromised immune system, is what causes AIDS. Zidovudine (AZT), an anti-HIV drug, serves as a treatment AIDS. It may be administered alone or in conjunction with antiviral medications. A substantial percentage of the AZT medication was shown to be imprisoned in the noisome created by the addition of Tween 80 in one study, where the addition of diacetyl phosphate caused a delay in the drug release of 88.72% over 12 hours. The molecular ratios

of the non-ionic surfactant with a constant ratio of cholesterol were altered during the formation of the niosomes, changing the entrapment efficiency and resulting in the observation of an AZT is released under control.

5) Niosome as carrier for haemoglobin:

transporter for haemoglobin is a niosome. Similar to non-capsulated haemoglobin in vesicles, which is easily permeable to oxygen, the haemoglobin curve can be modified. You can overlay the visible spectra of free haemoglobin with niosomal suspension.

6) Antibiotics:

A topical antibiotic that is water soluble is delivered to the eyes using the non-ionic surfactant vesicles (niosomes). The investigation into gentamicin sulphate revealed that niosomes are the most promising ocular transporters for topical gentamicin sulphate administration.

7) Protein and peptide

For the transportation of peptides and proteins, niosomes can be employed as an oral formulation with sustained release.

8) Transdermal delivery:

Niosomes have been investigated as transdermal drug delivery systems, as well as their capacity to improve drug absorption and lessen skin irritation through the intact stratum corneum. Using Franz diffusion cells, it was determined whether ketorolac (a strong NSAID) permeated through excised rabbit skin from different proniosomes gel formulations. The produced proniosomes greatly reduced lag time and improved medication penetration. The niosome used for several applications are mentioned in **Table 3**.

APPLICTION	COMPONENTS	METHOD USED	DRUG USED
Reduced toxicity	Span20, span30, span40, cholesterol	Thin film hydration	Cefpodoxime, Proxertil
To increase entrapment efficiency	Span 60, Cholesterol, DCP	Thin film hydration	Ketoprofen
For enhancement of therapeutic index	Span and Tween (20 and/or 60), Cholesterol	Reverse phase evaporation method	a-Lipoic acid
For liver targeting	Span 60, Cholesterol, DCP	Thin film hydration	Ribavirin
As a drug delivery carrier	a, w-Hexadecyl-bis-(1-aza)18- crown-6(bola), Span 80, Cholesterol	Thin layer evaporation technique	5-Fluorouracil
For sustained antiplatelet Effect	Cholesterol, Tween 60, Stearyl amine	Lipid hydration Method	indomethacin
To increase bioavailability	Cholesterol, Sorbitan monostearate (span 60), (DCP)	Thin film hydration	Acyclovir
For brain targeting	N-Palmitoyl glucosamine (NPG), Span 60, Cholesterol, Solana C24	Probe sonication Method	Vasoactive Intestinal Peptide
To prolong the release time	Sorbitan esters	Reverse phase evaporation method	Rifampicin
For drug targeting	monostearate (Span 60), Cholesterol, Glycol chitosan Sorbitan monostearate (span 60	Reverse phase evaporation method	Methotrexate
In leishmaniasis	Span 40, Cholesterol, DCP	Solvent evaporation Method	14-deoxy-11-oxoandograph-olide
In anticancer therapy	Span 60, Cholesterol, DCP	Lipid layer hydration Method	Bleomycin
In oral delivery of peptide Drug	Brij 52, Brij72, Brij92, Brij76, Brij97, Brij58, Brij35, DCP, Cholesterol	Film hydration Method	Insulin
In ophthalmic drug delivery System	Span 20, Span 60, Cholesterol	Thin layer hydration Method	Acetazolamide

6.2 MARKETED PRODUCTS

The Lancôme has used for variety of anti-aging product which are based on niosomal formulation. The L'Oréal is conducting the research on anti-aging cosmetic formulation. Lancôme is niosomal preparation present in market.



Figure 10: Lancôme

Table:4

Products	Drug
Niosomes	✓ Aceclofenac sodium ✓ Diclofenac sodium ✓ Ketoprofen ✓ Baclofen ✓ Salidroside ✓ Capsaicin ✓ Curcumin
Niosomal gel	✓ Aceclofenac ✓ Meloxicam ✓ Rofecoxib ✓ Simvastatin ✓ Proponolol Hcl ✓ Tyrosol ✓ Lopinavir
Elastic vesicles	Sulfadiazine sodium
Elastic vesicles gel	✓ Diclofenac diethylammonium ✓ Papain
Proniosomes	Vinpocetine

7. CONCLUSION:[19,20]

Niosomes are a novel and promising drug delivery technology. They are drug carriers who help to design an efficient drug delivery system. They provide an excellent opportunity for combining hydrophilic, lipophilic, or both drugs. Improved bioavailability, sustained release, controlled release, long circulation time, reduced dosage regimen, site specificity, and targeted delivery are all advantages of drug encapsulation in niosomes. Niosomes appear to be a better drug delivery system than liposomes because they are more stable and cost-effective. This system is widely accepted by academics and researchers alike. Niosomal formulations can be administered via oral, topical/transdermal, parenteral, and ocular routes to achieve both systemic and local effects. Niosomes have a high drug delivery potential for anticancer, anti-infective, anti-inflammatory, and transdermal drug delivery, as well as recently as a vaccine adjuvant and diagnostic agents. Based on the benefits listed above, we can conclude that niosomes are a very promising vesicular drug delivery system that can improve the overall therapeutic performance of drugs.

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