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A Review on A Nano Drug carrier: Niosomes

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Abstract : Niosomes are nonionic surfactant vesicles made by hydrating synthetic nonionic surfactants, either with or without cholesterol or its lipids. They're vesicular structures that look like liposomes and can transport both amphiphilic and lipophilic medicines. Noisomes are a viable vehicle for drug delivery due to their non-ionic nature, and niosomes are biodegradable, biocompatible, non8 immunogenic, and structurally flexible. For the treatment of cancer, viral infections, and other microbial disorders, niosomes have been extensively studied for controlled release and targeted administration. Niosomes can entrap both hydrophilic and lipophilic medicines, allowing them to circulate longer in the body. Encapsulation of a drug in the vesicular system is expected to prolong its presence in the systemic circulation and improve penetration into target tissue, as well as potentially lower toxicity if selective uptake is achieved. This review article focuses on the benefits, drawbacks, preparation techniques, and influencing factors.

***Key words*- Vesicles, Niosomes, Advantages, Preparation Methods, Characterization.**

I. INTRODUCTION

Novel vesicular drug delivery systems attempt to transport the active ingredient to the site of action at a rate determined by the body's needs during the treatment period. The biological origin of these vesicles was initially identified by Bingham in 1965, and they are known as Bingham bodies. To achieve targeted and regulated drug delivery, a number of innovative vesicular drug delivery systems have emerged, including diverse routes of administration[1]. Targeted drug delivery is a method of delivering a therapeutic agent to the tissues of interest while lowering the relative concentration of the therapeutic agent in other tissues, improving therapeutic efficacy and lowering side effects. Drug targeting refers to the delivery of medications to specific receptors, organs, or other targets.[2]
Vesicular Targeted drug delivery is two types as given in table1 [3]

Table 1: Vesicular Targeted drug delivery

Lipoidal biocarrier		Non-Lipoidal biocarrier
Liposomes	Enzymosomes	Bilosomes
Emulsomes	Ethosomes	Aquasome
Sphingosomes	Pharmacosomes	Niosomes
Transferosomes	Virosomes	

II. NIOSOMES:

In 1909, Paul Ehrlich predicted a way for delivering pharmaceuticals that would particularly target diseased cells, kicking off the history of controlled distribution. Drug directing is defined as the ability to accurately direct a beneficial product to the operation's target site with minimal non-target tissue disturbance. [4] In the niosome drug delivery technique, the medication is encased in a vesicle. Because the lipid membrane is made up of a bilayer of active non-ionic surface components, niosomes are named after them. [5-7] Niosomes are non-ionic surface-active agent vesicles that can be made non-heritable by combining artificial non-ionic surfactants with or without cholesterol or other lipids.[8] They're sac structures that look a lot like liposomes

and could be employed to carry amphipathic and lipotropic medicines. One of the reasons for generating niosomes is that the surface-active ingredient has a higher chemical strength than phospholipids, which are used in the manufacture of liposomes. Phospholipid is simply hydrolyzed due to the presence of an organic chemical bond [9].(Figure 1) Niosomes are multilameller vesicular structures of nonionic surfactants that resemble liposomes but are made up of nonionic surfactants rather than the phospholipids that make up liposomes. [10] Among these carriers, niosomes are one of the most effective. Researchers in the cosmetic sector initially documented the self-assembly of non-ionic surfactants into vesicles in the 1970s.[11] L'Oreal created and patented the first niosome formulations in 1975. [12] They're liposome-like vesicles made up of hydrated cholesterol, a charge-inducing chemical, and nonionic surfactants like monoalkyl or dialkyl polyoxyethylene ether. [13,14] The exact mechanism of vesicle generation when nonionic surfactants are used is unknown. Because of their amphiphilic nature, nonionic surfactants are thought to create a closed bilayer in aqueous settings.(Fig:1)

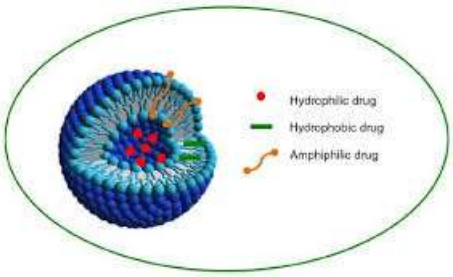

Fig: 1 Structure of Niosome

The formation of this structure necessitates some form of energy input, such as physical agitation (e.g., the handshaking method) or heat (e.g. using the heating method). The hydrophobic portions of the molecule are orientated away from the aqueous solvent in this closed bilayer form, whilst the hydrophilic head is in contact with the aqueous solvent.[15] Because of their unique structure as vesicular systems, niosomes can encapsulate both hydrophilic and lipophilic molecules. Lipophilic compounds are captured by partitioning into the lipophilic domain of the bilayers, whereas hydrophilic medicines are frequently enclosed in the inner aqueous core or adsorbed on the bilayer surfaces. Niosomes can encapsulate a great amount of material in a tiny volume of vesicular space. Because niosomes' structure protects therapeutic ingredients from a variety of conditions both inside and outside the body, they can be employed to deliver labile and sensitive medications. Niosomes boost drug molecules' therapeutic effectiveness by delaying their clearance from the circulation and limiting their effects to target cells. Niosomes can be given through a variety of routes, including oral, parenteral, and topical, and in a variety of dosage forms, including powders, suspensions, and semisolids, to improve the oral bioavailability of poorly soluble drugs and to improve drug permeability through the skin when applied topically.[16] The niosome is chosen as the carrier of choice among numerous nanovesicular carriers because it outperforms traditional liposomes in terms of stability and cost-effectiveness. Niosomes have numerous concentric bilayer membranes enclosing aqueous phase in the centre, which are mostly made up of nonionic surfactants and cholesterol. Niosomes have been shown to increase the solubility, bioavailability, and stability of some poorly soluble medicines, as well as their potential to deliver sustained pharmacological activity.[17] Because the vesicles can act as drug reservoirs, medication delivery by Niosomal vesicles has various advantages over traditional dosing modalities.[18] Niosomes have a unique shape that allows them to carry both hydrophilic and lipophilic medicines, making them an effective new drug delivery system (NDDS).19 Because of its potential to encapsulate various types of medications for the aim of boosting their stability and efficacy, niosomes may be a viable alternative to liposomes and polymersomes.[20] Because of the unreliable dependability caused by the use of emulsifier in liposomes, scientists are looking for vesicles made from other materials, such as non-ionic surface-active compounds. Because they are non-ionic, niosomes are a promising route for medication delivery. By prescribing its activity to focus on target cells, it is less cytotoxic and enhances the therapeutic index of the medicine. The vesicles generating amphiphile in niosomes could even be a non-ionic surface-active agent like Span –sixty, which is normally stabilised by cholesterol and a little amount of anionic surface-active agent like dicetyl-phosphate.[21] Niosomes are microscopic lamellar structures that range in size from ten to 1000 nanometers. Surfaceactive agents that are non-immunogenic, perishable, and biocompatible make up the niosome.[22]

III. Advantages of Niosomes [23-27]

1. The water-based vesicle suspension encourages patient compliance more than oil-based solutions.
2. Niosomes can be employed for a range of medications since its structure allows for hydrophilic, lipophilic, and amphiphilic drug moieties to be accommodated.
3. The size, lamellarity, and other features of the vesicle can be modified based on the demand.
4. The vesicles can operate as a depot, allowing the medicine to be released slowly and in a controlled manner.

IV. Other advantages of niosomes[28-31]

1. They are osmotically active and stable, for starters.
2. They improve the entrapped drug's stability.
3. Surfactant handling and storage do not necessitate any specific conditions.
4. Drugs oral bioavailability can be improved.
5. Aids drug penetration through the skin.
6. Oral, parenteral, and topical applications are all possible.
7. The surfactants are nonimmunogenic, biodegradable, and biocompatible.
8. Enhance the drug's therapeutic performance by shielding it from the biological environment and limiting its effects to target cells, lowering the drug's clearance.
9. To control the drug's release rate and administer normal vesicles in an external non-aqueous phase, niosomal dispersions in an aqueous phase can be emulsified in a non8aqueous phase.

V. Disadvantages of Niosomes[32-33]

1. Instability of the body
2. Fusion
3. Aggregation
4. Entrapped medication leakage
5. Encapsulated medicines are hydrolyzed, reducing the shelf life of the dispersion.

VI. COMPOSITION OF NIOSOMES:

The vital components used in the niosome formulation are:

- Non-ionic surfactants
- Cholesterol
- Charge inducer
- Hydration medium

- **Surface-active agents (non-ionic surfactants):** The surface-active agent is the most important component in the formulation of the noisome. They have a polar head and a non-polar tail [34] and are amphiphilic in nature. These agents are more stable, compatible and less harmful when compared to other surfactants such as anionic, cationic and amphoteric surfactants because they do not carry any charge. These compounds induce less haemolysis and cellular surface irritation. They can be employed as emulsifiers and wetting agents. Nonionic surfactants have the important property of inhibiting p-glycoprotein, which improves absorption and targeting [35]. of anticancer drugs (example-doxorubucin, daunorubicin, curcumin, morusin)[36-39],steroids (example-hydrocortisone)[40], HIV-protease inhibitor (example-ritonavir)[41], cardiovascular drugs (example-digoxin, beta-blockers)[42]. Non-ionic surfactants have a high level of interfacial activity and are made up of polar and non-polar groups and segments. The generation of bilayer vesicles is influenced by the hydrophiliclipophilic balance (HLB) scale, component chemical structure, and crucial packing parameter (CPP). The hydrophilic head group of a non-ionic surfactant's chain length and size affect drug entrapment

efficiency. The entrapment effectiveness of a nonionic surfactant with a longer alkyl chain is higher. The Tween surfactant sequence, which has an extended alkyl chain and a large hydrophilic moiety, has the best trapping efficiency of water soluble medicines when combined with cholesterol in a 1:1 ratio. A surfactant's HLB value is critical for preventing drug trapping in the vesicle it forms[43]. The area of the polar head group, as well as the volume and length of the non-polar group, can be used to compute the critical packing parameter (CPP) value of a surfactant. The sort of vesicle that will form can be determined using CPP values (Fig 2) and additionally by the use of a formula to calculate CPP.[44]

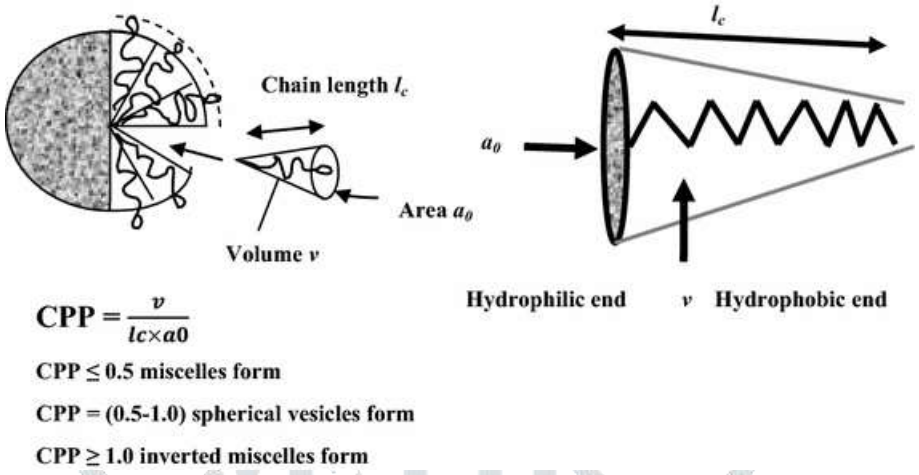

Fig: 2 the critical packing parameter

- **Cholesterol :** Cholesterol is a waxy steroid derivative found in cell membranes that is used to make niosomes. [45] The cell membrane's leakiness is reduced by integrating cholesterol into the bilayer structure of niosomes, which boosts the niosomes' trapping efficiency [46]. Cholesterol is commonly added to nonionic surfactants to provide hardness and appropriate niosomal bilayer direction/adjustment [47]. Cholesterol is known for preventing the niosomal system from transitioning from gel to liquid phase, resulting in less leaky niosomes. [48]

- **Charge inducers:** To avoid coalescence, charge inducers are added to the preparation to strengthen the stability of niosomes through electrostatic repulsion. Diacetyl phosphate (DCP) and phosphotidic acid are the most commonly employed negatively charged compounds. Stearyl amine (STR) and stearyl pyridinium chloride are both positively charged inducers utilised in niosomal preparations. Charged inducer concentrations of 2-5 mole percentages are tolerable since greater concentrations can obstruct niosome formation [49,50].

- **Hydration medium:** Phosphate buffer is the most often utilised hydration medium in the manufacture of niosomes. Phosphate buffers are employed at a variety of pH levels. The solubility of the medicine being encapsulated 51 determines the pH of the hydration media.[51]

VII.TYPES OF NIOSOMES[52,53]

The different types of niosomes can be classified as follows: (Fig 3).
1) Multilamellar vesicles (MLV)
2) Large unilamellar vesicles (LUV)
3) Small unilamellar vesicles (SUV)

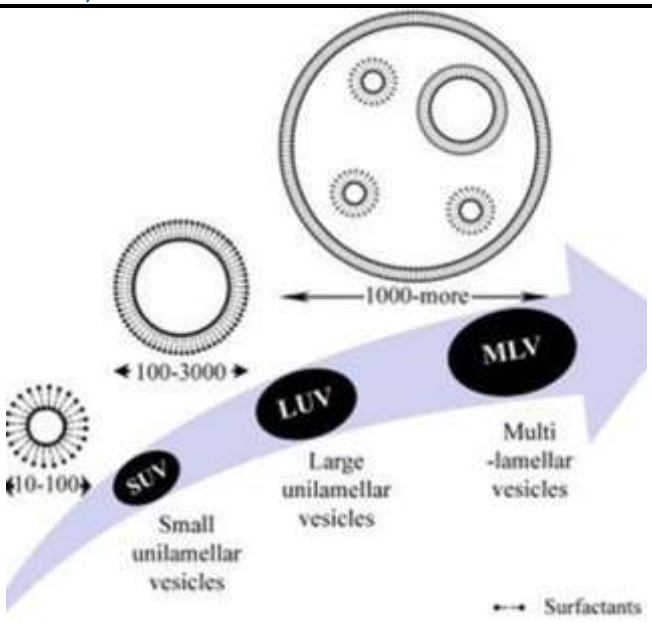

Fig: 3 Types of Niosome

1. **Multilamellar vesicles (MLV):** The most common niosome is multilamellar vesicles. The vesicles have a diameter of between 0.5 and 10 m. The vesicle preparation procedure is simple, and it remains mechanically stable over time. The aqueous lipid component is frequently surrounded by a number of bilayers. These miltilamellar vesicles are ideal for delivering lipophilic substances as a medication carrier.

2. **Large unilamellar vesicles (LUV):** Large unilamellar niosomes have a high aqueous/liquid compartment ratio, allowing for the entrapment of higher amounts of bioactive compounds with minimal membrane lipid consumption. Large unilamellar vesicles range in size from 100 to 3000 nm in length.

3. **Small unilamellar vesicles (SUVs):** The diameter of small unilamellar vesicles is 10–100 nm. Sonication, high-pressure homogenization, and extrusion are some of the methods used to create small unilamellar vesicles.

VIII. METHOD OF PREPARATION:

1. Hand shaking method (Thin film hydration technique)
2. Micro fluidization
3. Reverse Phase Evaporation (REV)
4. Ether Injection Method
5. Trans-membrane pH-gradient (inside acidic)
6. The Bubble Method
7. Sonication
8. Multiple extrusion method
9. Formation of niosomes from proniosomes

1. **Hand shaking method (Thin film hydration technique):** Non-ionic surfactant and cholesterol are dissolved in a volatile organic solvent in a round bottom flask using the hand shaking method (such as diethyl ether, chloroform, or methanol). At room temperature (20°C), the organic solvent is evaporated using a rotary evaporator, leaving a thin layer of solid mixture on the flask's wall. The dried surfactant film is hydrated with aqueous phase containing medication at 50-60°C with gentle agitation. Multilamellar niosomes are generated using this method [54,55].

2. **Micro-fluidisation** is a process for creating unilamellar vesicles with a predetermined size distribution. It works on the basis of the submerged jet principle, in which two fluidized streams interact in precisely defined micro channels within the interaction chamber at ultra-high velocities (100 ml/min). The impingement of a thin liquid sheet along a common front is arranged in such a way that the energy given to the system stays inside the niosome formation area. This approach produces niosomes with more uniformity, lower size, and improved reproducibility. [56,57,58].

3. **Reverse Phase Evaporation (REV):** The cholesterol and surfactant are taken in a 1:1 ratio in reverse phase evaporation. The aforesaid mixture is dissolved in a mixture of ether and chloroform. The drug is dissolved in water. Both mixtures are sonicated at a temperature of 4-6 degrees Celsius. The niosome suspension is diluted in PBS for 10 minutes at 60°C in a water bath, yielding niosomes. PBS is added to the resulting product and sonicated at low pressure while maintaining a temperature of 40-45°C. At this temperature, the organic phase is eliminated. To obtain niosomes [59,60].

4. **The ether injection method** includes injecting a surfactant solution containing diethyl ether (a volatile organic solvent) into warm water kept at 60°C to produce niosomes. A 14-gauge needle is used to inject the surfactant mixture in ether into an aqueous solution of material. When ether (volatile organic solvent) is vaporised, single-layered vesicles develop. [61]

5. **Trans-membrane pH-gradient (inside acidic):**Surfactant and cholesterol are mixed/ blended in a round bottom flask and dissolved in chloroform in the trans-membrane pH gradient (inside acidic) method. By evaporating the chloroform under reduced pressure, a thin film is formed on the flask's wall. Vortex mixing with 300mM citric acid is used to hydrate the film (pH 4.0). Aqueous solution containing 10mg/ml of medication is added to the aforementioned niosomal suspension and vortexed. By adding 1M disodium phosphate to the sample, the pH is adjusted to 7.0-7.2, and the mixture is heated at 60°C for 10 minutes. This approach results in multilamellar vesicles. [62,63,64].

6. **The bubble method** is a unique process for manufacturing niosomes that does not require the use of organic solvents. This approach makes use of the bubbling unit. The temperature is controlled by this apparatus, which consists of a round bottom flask with three necks positioned in a water bath. The first neck is filled with water-cooled reflux, the second neck is filled with a thermometer, and the third neck is filled with nitrogen. At 70°C, cholesterol and surfactant are combined in a buffer solution (pH-7.4). The solution is mixed for 15 seconds in a high shear homogenizer, and then it is immediately bubbled at 70°C using nitrogen gas [65,66]. (Figure 4).

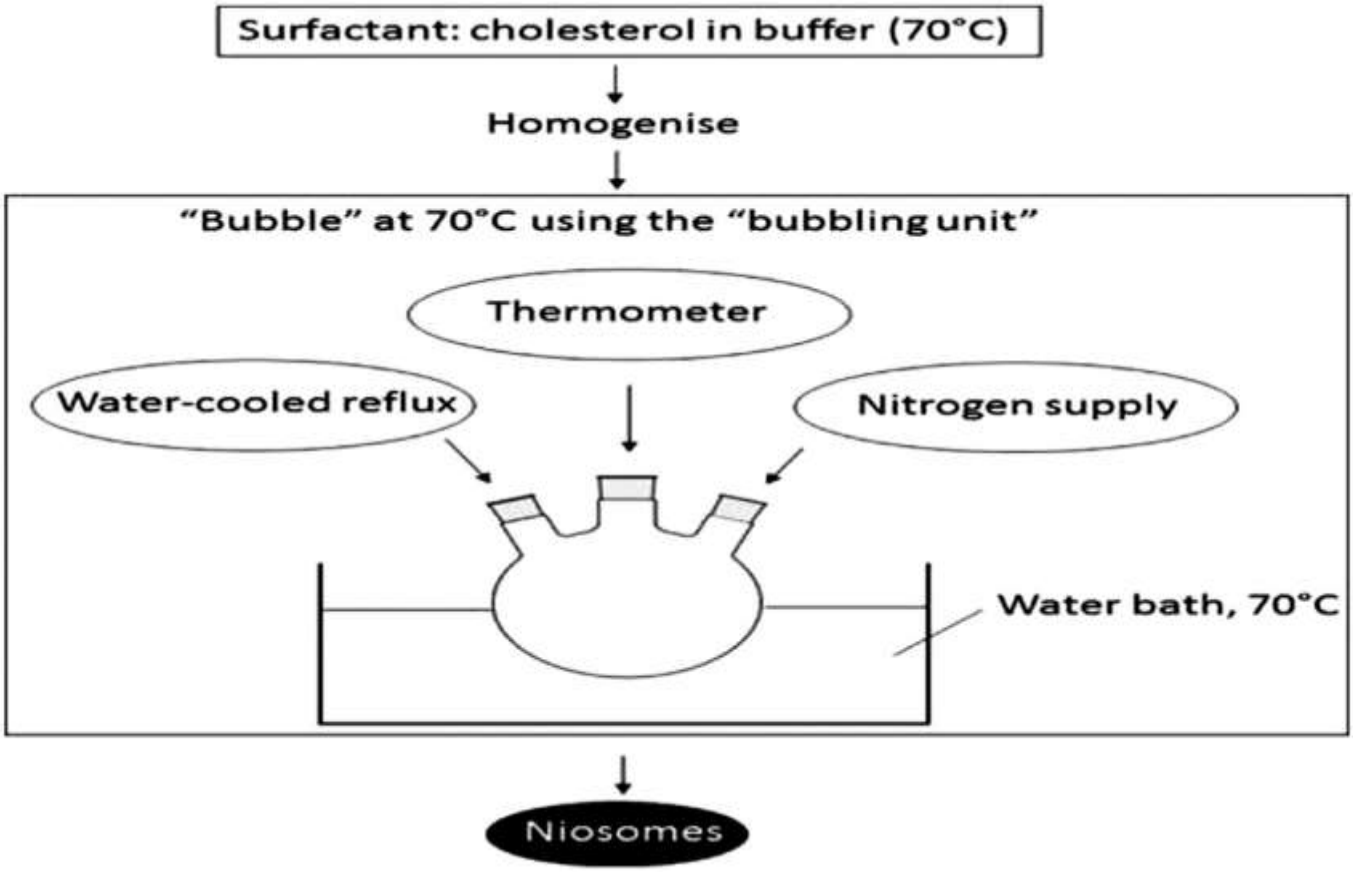

Figure 4: The bubble method

7. **Sonication:** One of the most common methods for preparing niosomes is sonication. The drug solution is made by dissolving the drug in buffer in this approach. The non-ionic surfactant mixture is then added at an optimal ratio to this buffer drug solution. Sonicating the combination at a specified frequency, temperature, and time yields the appropriate niosomes. It is one of the simplest methods for controlling the particle size of niosomes. The diameters of niosomes with a restricted size distribution can be reduced using this procedure. Probe sonicators can be used as well, but they require a lot of energy. As a result, the temperature rises quickly, and titanium is released.[67]

8. **Membrane Extrusion Procedure:** Surfactant, cholesterol, and diacetyl phosphate are combined in chloroform in this method. The chloroform mixture is then evaporated, yielding a thin film. Aqueous drug polycarbonate membrane is used to hydrate the thin film. This membrane extrudes the solution and the resulting suspension (which consist of 8 passages). This approach also yields the required size of niosomes [68,69].

9. **Niosome synthesis from proniosomes:** Niosomes are formed by adding an aqueous phase containing a medication to preniosomes with short agitation at a temperature higher than the surfactant's mean transition phase temperature [70]. T Tm Tm = Mean phase transition temperature, where T = Temperature The formation of niosomes from maltodextrin-based preniosomes was described by Blazek-Walsh A.I et al. This formulation provides quick niosome reconstitution with minimal leftover/residual carrier. The formulation was made into a free-flowing powder by drying a slurry of maltodextrin and surfactant that could be rehydrated with warm water [71,72].

IX. SEPARATION OF UNENTRAPPED DRUG :

1. **Dialysis:** Phosphate buffer, glucose solution, or normal saline are used to dialyze the aqueous niosomal suspension in dialysis tubing.
2. **Gel Filtration:** The unentrapped drug in the niosomal suspension is extracted using a Sephadex-G-50 column and eluted with phosphate buffered saline or normal saline.

3. **Centrifugation:** Centrifugation separates the supernatant liquid from the niosomal suspension. By washing the pellet and resuspending the solution, niosomal suspension free of unentrapped medication is obtained.[73,74]

X. NIOSOMES VERSUS LIPOSOMES:

Liposomes and niosomes are nearly identical in nature. Liposomes include phospholipids that are unstable in nature, whereas niosomes contain non-ionic surfactants that are. Liposomes are made from double-chain phospholipids, whereas niosomes are made from unaltered single-chain non-ionic surfactants. Niosomes are 10-100nm in size, while liposomes are 10-300nm. When it comes to pricing, niosomes are less expensive than liposomes.[75]

XI. FACTORS AFFECTING THE NIOSOME FORMATION:

1. **Medication:** The charge and stiffness of the niosomal bilayer are directly affected by the physico-chemical characteristics of the encapsulated drug. Entrapping the medication inside the niosomes, as well as interaction of the solute with surfactant head groups, increases the vesicle size of the niosomes. The vesicle size is increased by increasing the charge and mutual repulsion between the surfactant bilayers. The Hydrophilic-Lipophilic balance of the medication also influences the degree of entrapment.[76,77]

2. **Resistance of Osmotic stress:** When a hypertonic salt solution is added to a niosomal suspension, the diameter of the niosomes shrinks. Again, the addition of hypotonic salt solution causes sluggish release and minor enlargement of the vesicles due to the suppression of vesicle elution fluid. Due to mechanical weakening of the vesicle structure under osmotic stress, the release becomes faster.[78]

3. **Temperature of hydration medium:** The temperature of the hydration media is critical for vesicle production. This has an impact on their shape and size. The temperature should be kept above the system's gel to liquid phase transition point. Temperature-induced changes in vesicle shape have also been documented. It also has an impact on surfactant vesicle assembly. The volume of hydration media and the duration of the lipid film have an impact on vesicle shape and yield.[79]

4. **Cholesterol content:** Cholesterol has an effect on the niosomes' physical characteristics and structure. The presence of non-ionic surfactants has an effect on the structure. Cholesterol is found in biological membranes and influences ion permeability, aggregation, fusion processes, membrane size, shape, elasticity, and enzymatic activity. When cholesterol is added to niosomes, the fluidity of the niosomes changes. Cholesterol is vital for the creation of niosomes because it gives vesicles stiffness, which is important under stressful conditions. The amount of cholesterol to be added is determined by the surfactant's HLB value. To compensate for the larger head groups, the amount of cholesterol should be increased as the HLB value rises above 10. Changes in the HLB value have an effect on the amount of noise.[80] Cholesterol improves the hydrodynamic diameter and trapping effectiveness of niosomes. The gel state is changed into a liquid ordered phase at high cholesterol concentrations. The release rate of encapsulated material decreases as the cholesterol content of the bilayers increases, increasing the stiffness of the bilayers obtained [81]..

5. **Amount and type of surfactant:** Because the surface free energy reduces as the hydrophobicity of the surfactant increases, the mean size of niosomes increases proportionally with the increase in HLB surfactants like Span 85 (HLB 1.8) to Span 20 (HLB 8.6). Depending on the temperature, the type of surfactant, and the presence of additional 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 distinguishes surfactants and lipids (TC). The entrapment efficiency of a surfactant is

also affected by its phase transition temperature (TC), for example, Span 60 having higher TC, provides better entrapment.[82]

6. **Membrane Composition:** The addition of numerous chemicals, as well as surfactants and medicines, results in the development of stable niosomes. Niosomes are created with a range of morphologies, and their permeability/porousness and stability attributes can be changed by modifying membrane properties with completely distinct additions. The shape of polyhedral niosomes generated from C16G2 is unaltered due to the inclusion of a little amount of solulan C24 (cholesterol poly-24-oxyethylene ether) solution, which prevents aggregation due to the development of steric hindrance.[83]

XII. CHARACTERIZATION OF NIOSOMES:

1. **Entrapment Efficiency:** The amount of active chemicals loaded within the niosomal structure is the entrapment efficiency (EE) of vesicular systems. It can be written as EE = x 100, where "total quantity" refers to the total amount of medication in the niosomal formulation. Using a UV-visible spectrophotometer, the entrapment efficiency is assessed spectrophotometrically. Gel electrophoresis is carried out on genetic material, followed by UV densitometry. Furthermore, employing a hydrophilic fluorescent, the entrapment efficiency may be fluorometrically assessed.[84]

2. **Size and shape of vesicles:** The shape of niosomal vesicles is considered to be spherical, and the mean diameter of these vesicles can be calculated using the laser light scattering method. Electron microscopy, molecular sieve chromatography ultracentrifugation, photon microscopy and optical microscopy, and freeze fracture electron microscopy can also be used to assess the diameter of these vesicles. The vesicle width increases when frozen niosomes are thawed, which could contribute to vesicle fusion during the cycle. [64]

3. **In-vitro release:** A dialysis membrane approach is commonly employed in in-vitro release studies. A little amount of niosomes is placed in a dialysis bag and knotted at both ends in this procedure. A beaker containing adequate dissolving media is kept at 37 °C, and the dialysis bag is inserted into it and agitated with a magnetic stirrer. At certain intervals, a sample solution is removed from the beaker and replaced with new dissolving medium. The samples were evaluated for drug concentrations at specific wave lengths as indicated in the appropriate medication monograph [85].

4. The number of lamellae in niosomes can be determined using an electron microscope, NMR spectroscopy, or the X-ray scattering approach.[59]

5. **Membrane rigidity:** Membrane rigidity of the noisome is determined as a function of temperature using the mobility of a fluorescent probe.[75]

6. **Bilayer formation :** Under light polarisation microscopy, the creation of an X-cross indicates the assembly of non-ionic surfactants to create a bilayer vesicle.[86]

7. The stability of niosomes can be assessed by measuring mean vesicle size, size distribution, and entrapment efficiency after several months of niosomal suspension storage at various temperatures. Niosomes are sampled at regular intervals throughout storage, and the percentage of medication retained in the niosomes is determined by UV spectroscopy or HPLC procedures [87].

8. **Vesicular surface charge:**To prevent the aggregation of produced vesicles, charged molecules are usually included in the bilayer while making niosomes. When dicetyl phosphate, a charged molecule, was introduced into vesicles, there was a reduction in vesicle aggregation. The charge on vesicles is computed using Henry's equation: [70], which is stated in terms of zeta potential. $=,

where £ denotes the Zeta potential. E stands for electrophoretic mobility. = Medium's viscosity Dielectric constant is a term used to describe the dielectric properties of a material.

XIII. APPLICATIONS OF NIOSOMES:

1. **Targeting of bioactive agents:**
   a. **To reticulo-endothelial system (RES):** The RES cells preferentially consume the vesicles. It can be used to treat animal cancers that have spread to the liver and spleen, as well as parasitic infestations of the liver.
   b. **To organs other than RES:** It has been suggested that carrier system system reaches at specific site in the body by the use of antibodies. Immunoglobulin is a convenient means for targeting of drug carrier [88].

2. **For the treatment of Leshmaniasis:** Leishmaniasis is a parasitic infection that affects the cells and liver. Antimonials are the most often used medications. The antimony investigation on mice found that increasing sodium stibogluconate efficacy of niosomal formulation improved sodium stibogluconate efficacy, and the effect of two doses on consecutive days was additive. In experimental leishmaniasis, niosomes are also efficacious as loaded drug liposomes [89].

3. **Tumor targeting:** A large concentration of anticancer drug is necessary at the tumour location for successful cancer treatment. This reduces the concentration of the drug in other body tissue compartments, reducing the risk of unwanted responses. Several organisations have investigated niosomes for improved delivery of anticancer drugs to regional lymphatics. They generated cytarabine hydrochloride niosomes using a lipid hydration method that did not use dicetyl phosphate to obtain smaller vesicles. The vesicles obtained ranged in size from 600 to 1000nm. The Span 60 formulation had the slowest release rate among the surfactants tested (Span 60, Span 80, Tween 20, Tween 80). The release was split into two phases: an initial burst that lasted 2–6 hours, followed by a continuous release that lasted at least 24 hours.[90]

4. **For the treatment of AIDS:** AIDS is caused by the human immunodeficiency virus (HIV), which is characterised by a severely weakened immune system. Zidovudine (AZT) is an anti-HIV drug that is used to treat AIDS. It can be used on its own or in combination with antiviral medications. In one investigation, the noise created by adding Tween 80 revealed a large amount of AZT drug entrapped, and the addition of diacetyl phosphate boosted the drug release for a longer period of time (88.72 percent over 12 hours). The entrapment efficiency was adjusted during the formation of niosomes by changing the molecular ratios of non-ionic surfactant with a constant ratio of cholesterol, and regulated release of AZT was observed [91].

5. **Niosomes as haemoglobin carriers:** Niosomes are employed as haemoglobin carriers. The haemoglobin curve can be changed similarly to non-capsulated haemoglobin because vesicles are easily permeable to oxygen. The visible spectrum of niosomal suspension can be superimposed on that of free haemoglobin. [68]

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7. **Protein and peptide:** Niosomes can be used as a long-acting oral formulation for peptide and protein transport [93]

8. **Transdermal delivery:** Niosomes as a transdermal drug delivery system were investigated, as well as their capacity to improve drug absorption and reduce skin irritation through the intact stratum corneum. Using Franz diffusion cells, the permeation of ketorolac (a powerful NSAID) over excised rabbit skin from various proniosome gel formulations was examined. The produced proniosomes increased drug penetration and decreased lag time by percent. [94]

XIV. FUTURE PROSPECTS:

A possible medicine delivery mechanism is the niosome. Noisome can be used to encapsulate hazardous medications such as anti-cancer, antiviral, anti-AIDS, and other pharmaceuticals in order to improve their bioavailability and targeting properties. Niosomes do not require special storage or handling conditions.

XV. CONCLUSION:

Niosomes are an innovative and promising drug delivery system. They serve as drug carriers in the development of a successful medication delivery system. They are ideal for loading hydrophilic, lipophilic, or both medicines at the same time. Niosomes have been shown in numerous trials to improve the stability of entrapped drugs, reduce dosage, and allow targeted administration to a specific spot. Because niosomes are stable and inexpensive, they appear to be a better drug delivery mechanism than liposomes. Researchers and academicians alike have embraced this system. Niosomes offer a lot of potential as a drug delivery vehicle for anticancer, anti-infective, anti-inflammatory, transdermal drug delivery, vaccine adjuvants, and diagnostic compounds.

XVI. REFERENCES

[1] Biju, S. S., Talegaonkar, S., Mishra, P. R., & Khar, R. K. (2006). Vesicular systems: an overview. Indian journal of pharmaceutical sciences, 68(2).

[2] Kamboj, S., Saini, V., Magon, N., Bala, S., & Jhawat, V. (2013). Vesicular drug delivery systems: a novel approach for drug targeting. International Journal of Drug Madhav, N. V. S., & Saini, A. (2011). Niosomes: a novel drug delivery system. International journal of research in pharmacy and chemistry, 1(3), 498-511.

[3] Allen, T. M. (1998). Liposomal drug formulations. Drugs, 56(5), 747-756.

[4] Handjani-Vila, R. M., Ribier, A., Rondot, B., & Vanlerberghie, G. (1979). Dispersions of lamellar phases of non-ionic lipids in cosmetic products. International journal of cosmetic Science, 1(5), 303-314.

[5] Kemps, J., & Crommelin, D. A. (1988). Hydrolyse van fosfolipiden in watering milieu. Pharm. Weekbl, 123, 355-363.

[6] Rajera, R., Nagpal, K., Singh, S. K., & Mishra, D. N. (2011). Niosomes: a controlled and novel drug delivery system. Biological and Pharmaceutical Bulletin, 34(7), 945-953.

[7] Kazi, K. M., Mandal, A. S., Biswas, N., Guha, A., Chatterjee, S., Behera, M., & Kuotsu, K. (2010). Niosome: a future of targeted drug delivery systems. Journal of advanced pharmaceutical technology & research, 1(4), 374.

[8] Mahale, N. B., Thakkar, P. D., Mali, R. G., Walunj, D. R., & Chaudhari, S. R. (2012). Niosomes: novel sustained release nonionic stable vesicular systems—an overview. Advances in colloid and interface science, 183, 46-54.Delivery, 5(2), 121-130

[9] Uchegbu, I.F., Florence, A.T., Non-Ionic Surfactant Vesicles (Niosomes) Physical And Pharmaceutical Chemistry. Adv. Coll. Interf. Sci., 1995; 58: 1-55.

[10] Kumar, D., Sharma, D., Singh, G., Singh, M., & Rathore, M. S. (2012). Lipoidal soft hybrid biocarriers of supramolecular construction for drug delivery. International Scholarly Research Notices, 2012.

[11] Jeganath, S., Nitish, B., & Khalifa, F. K. A. (2020). Niosomes as target drug delivery system: A Review. Int. J. Res. Pharm. Sci, 11(3), 3198-3203.

[12] Baillie, A. J., Florence, A. T., Hume, L. R., Muirhead, G. T., & Rogerson, A. (1985). The preparation and properties of niosomes—non-ionic surfactant vesicles. Journal of pharmacy and pharmacology, 37(12), 863-868.

[13] Namdeo, A., &Namdeo, A., & Jain, N. K. (1996). Niosomes as drug carriers. Indian journal of pharmaceutical sciences, 58(2), 41.

[14] Biswal S, Murthy PN, Sahu J, Sahoo P, Amir F. Vesicles of non-ionic surfactants (niosomes) and drug delivery potential. Int J Pharm Sci Nanotechnol. 2008; 1(1):1-8.

[15] Reddy, B. S., Padman, J. S. C., & Santosh, V. (2012). Niosomes as nanocarrier systems: a review. International Journal of Pharmaceutical Sciences and Research, 3(6), 1560.
[16] Muzzalupo, R., & Tavano, L. (2015). Niosomal drug delivery for transdermal targeting: recent advances. Research and reports in transdermal drug delivery, 4, 23-33.
[17] Patel, K. K., Kumar, P., & Thakkar, H. P. (2012). Formulation of niosomal gel for enhanced transdermal lopinavir delivery and its comparative evaluation with ethosomal gel. AAPS pharmscitech, 13(4), 1502-1510.
[18] Pandita, A., & Sharma, P. (2013). Pharmacosomes: an emerging novel vesicular drug delivery system for poorly soluble synthetic and herbal drugs. International Scholarly Research Notices, 2013
[19] Moghassemi, S., & Hadjizadeh, A. (2014). Nano-niosomes as nanoscale drug delivery systems: an illustrated review. Journal of controlled release, 185, 22-36.
[20] Ge, X., Wei, M., He, S., & Yuan, W. E. (2019). Advances of non-ionic surfactant vesicles (niosomes) and their application in drug delivery. Pharmaceutics, 11(2), 55. Ge, X., Wei, M., He, S., & Yuan, W. E. (2019). Advances of non-ionic surfactant vesicles (niosomes) and their application in drug delivery. Pharmaceutics, 11(2), 55.
[21] Rai, A. K., Alam, G., Singh, A. P., & Verma, N. K. (2017). Niosomes: An approach to current drug delivery-A Review. International Journal of Advances in Pharmaceutics, 6(2), 41-48.
[22] Kaur, D., & Kumar, S. (2018). Niosomes: present scenario and future aspects. Journal of drug delivery and therapeutics, 8(5), 35-43.
[23] Usman, M. R. M., Ghuge, P. R., & Jain, B. V. (2017). Niosomes: a novel trend of drug delivery. European Journal of Biomedical and Pharmaceutical Sciences, 4(7), 436-442.
[24] Arunachalam, A., Jeganath, S., Yamini, K., & Tharangini, K. (2012). Niosomes: a novel drug delivery system. International journal of novel trends in pharmaceutical sciences, 2(1), 25-31.
[25] Uchegbu, I. F., & Vyas, S. P. (1998). Non-ionic surfactant based vesicles (niosomes) in drug delivery. International journal of pharmaceutics, 172(1-2), 33-70.
[26] Ag Seleci, D., Seleci, M., Walter, J. G., Stahl, F., & Scheper, T. (2016). Niosomes as nanoparticular drug carriers: fundamentals and recent applications. Journal of nanomaterials, 2016.
[27] Alsarra, I. A., Bosela, A. A., Ahmed, S. M., & Mahrous, G. M. (2005). Proniosomes as a drug carrier for transdermal delivery of ketorolac. European journal of pharmaceutics and biopharmaceutics, 59(3), 485-490.
[28] Singh, S. (2013). Niosomes: A role in targeted drug delivery system. International Journal of Pharmaceutical Sciences and Research, 4(2), 550.
[29] Shirsand, S. B., & Keshavshetti, G. G. (2019). Recent advances in niosomal drug delivery—A review. Res. J. Life Sci. Bioinform. Pharm. Chem. Sci, 3, 514-531.
[30] Kalra, N., & Jeyabalan, G. (2016). Niosomes: A versatile drug delivery system. Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences, 2(4), 44-54.
[31] Bhat, M. I., Ganesh, N. S., Majeed, T., & Chandy, V. (2019). Niosomes a controlled and novel drug delivery system: A brief review. World journal of Pharmaceutical sciences, 3(8), 481-497.
[32] Sharma, D., Ali, A. A. E., & Aate, J. R. (2018). Niosomes as novel drug delivery system. PharmaTutor, 6(3), 58-65.
[33] Sudheer, P., & Kaushik, K. (2015). Review on Niosomes-a Novel Approach for Drug Targeting. Journal of Pharmaceutical Research, 14(1), 20-25.
[34] Moghassemi, S., & Hadjizadeh, A. (2014). Nano-niosomes as nanoscale drug delivery systems: an illustrated review. Journal of controlled release, 185, 22-36.
[35] Zhang, S., & Morris, M. E. (2005). Efflux transporters in drug excretion. Drug delivery: principles and applications. Wiley, Hoboken, 381-398.
[36] Bhatt, P., Lalani, R., Vhora, I., Patil, S., Amrutiya, J., Misra, A., & Mashru, R. (2018). Liposomes encapsulating native and cyclodextrin enclosed paclitaxel: Enhanced loading efficiency and its pharmacokinetic evaluation. International journal of pharmaceutics, 536(1), 95-107.

[37] Shtil AA, Grinchuk TM, Tee L, Mechenter EB, and Ignatova TN. Overexpression of P-glycoprotein is associated with a decreased mitochondrial transmembrane potential in doxorubixin selected K562 human leukemia cells. International Journal of Oncology, 2000; 17: 387–392

[38] Agarwal, S., Mohamed, M. S., Raveendran, S., Rochani, A. K., Maekawa, T., & Kumar, D. S. (2018). Formulation, characterization and evaluation of morusin loaded niosomes for potentiation of anticancer therapy. RSC advances, 8(57), 32621-32636.

[39] Naderinezhad, S., Amoabediny, G., & Haghiralsadat, F. (2017). Co-delivery of hydrophilic and hydrophobic anticancer drugs using biocompatible pH-sensitive lipid-based nano-carriers for multidrug-resistant cancers. RSC advances, 7(48), 30008-30019.

[40] Ueda, K., Okamura, N., Hirai, M., Tanigawara, Y., Saeki, T., Kioka, N., ... & Hori, R. (1992). Human P-glycoprotein transports cortisol, aldosterone, and dexamethasone, but not progesterone. Journal of Biological Chemistry, 267(34), 24248-24252.

[41] Perloff, M. D., Von Moltke, L. L., Marchand, J. E., & Greenblatt, D. J. (2001). Ritonavir induces P-glycoprotein expression, multidrug resistance-associated protein (MRP1) expression, and drug transporter-mediated activity in a human intestinal cell line. Journal of pharmaceutical sciences, 90(11), 1829-1837.

[42] Kumar, G. P., & Rajeshwarrao, P. (2011). Nonionic surfactant vesicular systems for effective drug delivery—an overview. Acta pharmaceutica sinica B, 1(4), 208-219.

[43] Arunothayanun, P., Bernard, M. S., Craig, D. Q. M., Uchegbu, I. F., & Florence, A. T. (2000). The effect of processing variables on the physical characteristics of non-ionic surfactant vesicles (niosomes) formed from a hexadecyl diglycerol ether. International journal of pharmaceutics, 201(1), 7-14.

[44] 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.

[45] Nasir, A., Harikumar, S. L., & Amanpreet, K. (2012). Niosomes: an excellent tool for drug delivery. international journal of research in pharmacy and chemistry, 2(2), 479-487.

[46] Girigoswami, A., Das, S., & De, S. (2006). Fluorescence and dynamic light scattering studies of niosomes-membrane mimetic systems. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 64(4), 859-866.

[47] Rogerson, A., Cummings, J., & Florence, A. T. (1987). Adriamycin-loaded niosomes: drug entrapment, stability and release. Journal of microencapsulation, 4(4), 321-328.

[48] Rogerson, A. C. J. W. N. F. A. T., Cummings, J., Willmott, N., & Florence, A. T. (1988). The distribution of doxorubicin in mice following administration in niosomes. Journal of pharmacy and pharmacology, 40(5), 337-342.

[49] Louis, D., Mahmoud, K., Mohamed, M., & Ibrahim, A. (2018). An overview on niosomes: a drug nanocarrier. Drug Des Intellect Prop Int J, 143-51.

[50] Kauslya, A., Borawake, P. D., Shinde, J. V., & Chavan, R. S. (2021). Niosomes: A Novel Carrier Drug Delivery System. Journal of Drug Delivery and Therapeutics, 11(1), 162-170.

[51] Khan, R., & Irchhaiya, R. (2016). Niosomes: a potential tool for novel drug delivery. Journal of pharmaceutical investigation, 46(3), 195-204.

[52] Dwivedi, C., Kumar, B., Tiwari, S. P., Satapathy, T., Yadav, R., Sahu, G., & Roy, A. (2014). Niosomes: an excellent tool for drug delivery. Int. J. of Res. in Pharmacology and Pharmacotherapeutics, 3(3), 192-204.

[53] Durak, S., Esmaeili Rad, M., Alp Yetisgin, A., Eda Sutova, H., Kutlu, O., Cetinel, S., & Zarrabi, A. (2020). Niosomal drug delivery systems for ocular disease—recent advances and future prospects. Nanomaterials, 10(6), 1191.

[54] More, V. V. (2019). Niosomal drug delivery-a comprehensive review. Asian Journal of Pharmaceutics (AJP): Free full text articles from Asian J Pharm, 12(04).

[55] Baillie, A. J., Coombs, G. H., Dolan, T. F., & Laurie, J. (1986). Non-ionic surfactant vesicles, niosomes, as a delivery system for the anti-leishmanial drug, sodium stibogluconate. Journal of pharmacy and pharmacology, 38(7), 502-505.

[56] CHAVDA, V. P., DESAI, S., & SONIWALA, M. (2016). Indian Journal of Novel Drug Delivery. Indian Journal of Novel Drug Delivery, 8(3), 133-156. CHAVDA, V. P., DESAI, S., & SONIWALA, M. (2016). Indian Journal of Novel Drug Delivery. Indian Journal of Novel Drug Delivery, 8(3), 133-156.
[57] Frank LS and Huang L. Large scale production of DC-Chol cationic liposomes by microfluidization. International Journal of Pharmaceutics, 1996; 144(2): 131–139
[58] Sorgi, F. L., & Huang, L. (1996). Large scale production of DC-Chol cationic liposomes by microfluidization. International journal of pharmaceutics, 144(2), 131-139.
[59] Gowda DV, Jain SC, Gupta NV, Kulkarni PK. A brief review on niosomes. Journal of Pharmacy Research, 2017; 11(5): 450-458.
[60] Raja NR, Pillai GK, Udupa N, Chandrashekar G. Antiinflammatory activity of niosome encapsulated diclofenac sodium in arthritic rats. Indian Journal of Pharmacology, 1994; 26(1): 46-48.
[61] Sunilkumar MR, AdlinJinoNesalin J, Man TT. Niosome as a novel drug delivery system-review. Internationa Research Journal of Pharmaceutical and Applied Siences, 2015; 5(3): 1-7.
[62] Lohumi A, Rawat S, Sarkar Si, Sipai AB, Yadav MV. A novel drug delivery system: niosomes review. Journal of Drug Delivery & Therapeutics, 2012; 2(5): 129-135.
[63] Mayer LD, Bally MB, Hope MJ, Cullis PR. Uptake of antineoplastic agents into large unilamellar vesicles in response to a membrane potential. Biochem Biophys Acta, 1985; 816(2): 294- 302.
[64] Kuotsu K, Karim MK, Mandal AS, Biswas NGuha A, Chatterjee S, Behera M. Niosome: a future of targeted drug delivery systems. J Adv Pharm Tech Res., 2010; 4(1): 374-380.
[65] Navya MN, Parthiban S, Neasalin JAJ, Vikneswari A. Niosomes as novel vesicular drug delivery system- a review. Asian Journal of Research in Biological and Pharmaceutical Sciences, 2014; 2(2): 62-68.
[66] Chauhan S, Luorence MJ. The preparation of polyoxyethylene containing non-ionic surfactant vesicles. J Pharm Pharmacol., 1989; 41(6).
[67] Yuan WE, Xuemei Ge, Minyan Wei, Suna H. Advances of nonionic surfactant vesicles (niosomes) and their application in drug delivery. Pharmaceutics, 2019; 11(2): 1-16.
[68] Yadav JD, Kulkarni PR, Vaidya KA, Shelke GT. Niosomes: a review. Journal of Pharmacy Research, 2011; 4(3): 632-636.
[69] Khanam N, Alam MI, Sachan AK, Gangwar SS, Sharma R. Recent trends in drug delivery by niosomes: a review. Asian Journal of Pharmaceutical Research and Development, 2013; 1(3): 115- 122.
[70] Sudhamani T, Priyadarisini N, Radhakrishnan M. Proniosomes - a promising drug carriers. International Journal of PharmTech Research, 2010; 2(2): 1446-1454.
[71] Almira I, Blazek-Welsh, Rhodes DG. Maltodextrin-Based Proniosomes. AAPS Pharm SciTec., 2001; 3(1): 1-8.
[72] Blazek-Walsh AI and Rhodes DG. SEM imaging predicts quality of niosomes from maltodextrin-based proniosomes. Pharmceutical Research, 2001; 18: 656-661.
[73] Gandhi M, Paralkar S, Sonule M, Dabhade D and Pagar S. Niosomes: novel drug delivery system. International Journal of Pure and Applied Bioscience, 2014; 2(2): 267-274.
[74] Akhilesh D, Kamath JV. Review on span-60 based non-ionic surfactant vesicles as novel drug delivery. International journal of research in pharmaceutical and biomedical sciences, 2012; 3(1): 6-12.
[75] Nagalakshmi, Aruljothy M, Shanmuganathan S. An overview on niosome as carrier in dermal drug delivery. Journal of Pharmaceutical science and Research, 2015; 7(11): 923-927.
[76] 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.
[77] Cummings J, Staurt JF, Calman KC. Determination of adriamycin, adriamycinol and their 7-deoxyaglycones inhuman serum by high performance liquid chromatography. Journal of Chromatography, 1984; 311: 125-33.

[78] Vadlamudi CH, Sevukarajan M. Niosomal drug delivery systema review. Indo American Journal of Pharmceutical Research, 2012; 2(9). Kauslya et al Journal of Drug Delivery & Therapeutics. 2021; 11(1):162-170 ISSN: 2250-1177 [170] CODEN (USA): JDDTAO

[79] Nasseri B. Effect of cholesterol and temperature on the elastic properties of niosomal membranes. International Journal of Pharmaceutics, 2005; 300: 95-101.

[80] Mahale NB, Thakkar PD, Mali RG, Walunj DR, Chaudhari SR. Niosomes: novel sustained release nonionic stable vesicular systems - an overview. Advances in Colloid and Interface Science, 2012; 183-184: 46–54.

[81] 66. Sarker A, Shimu IJ, Alam SAA. Niosome: as dermal drug delivery tool. IOSR Journal of Pharmacy and Biological Science, 2015; 10(2): 73-79.

[82] 67. Sakthivel M, Kannan K, Manavalan, Senthamarai. Non-ionic surfactant vesicles-a review. Research Journal of Pharmaceutical, Biological and Chemical, 2012; 3(1):604-614.

[83] 68. Jindal K. Niosomes as a potential carrier system: a review. International Journal of Pharmaceutical, Chemical and Biological Sciences, 2015; 5(4): 947-959.

[84] 69. Carafa M, Marianecci C, Marzio LD, Rinaldi F, Celia C, Donatella Paolino D , Alhaique F, Esposito S. Niosomes from 80s to present: the state of the art. Advances in Colloid and Interface Science, 2014; 205: 187-206.

[85] 70. Singh SK, Rajera R, Nagpal K, and Mishra D. Niosomes: a Controlled and novel drug delivery system. Biological and Pharmaceutical Bulletin, 2011; 34(7): 945-953.

[86] 71. Gandhi A, Sen SO, Paul A. Current trends in niosome as vesicular drug delivery system. Asian Journal of Pharmacy and Life Science, 2012; 2 (2): 339-353.

[87] 72. Stahl F, Seleci DA, Seleci M, Walter JG, and Scheper T. Niosomes as nanoparticular drug carriers: fundamentals and recent applications. Hindawi Publishing Corporation Journal of Nanomaterials, 2016; 2016: 1-13.

[88] Mujoriya R, Bodla RB, Dhamande K, Singh D and Patle L. Niosomal drug delivery system: the magic bullet. Journal of Applied Pharmaceutical Science, 2011; 1(9): 20-23.

[89] Kalra N, Jeyabalan G, Singh G, Choudhary S. Non- ionic surfactant vesicles and their therapeutics potentials. Journal of Innovations in Pharmaceuticals and Biological sciences, 2(2): 193-201.

[90] Azeem A, Anwer MK and Talegaonkar S. Niosomes in sustained and targeted drug delivery: some recent advances. Journal of Drug Targeting, 2009; 17(9): 671-689.

[91] Koh RY, Yeo PL, Chye SM and Ling APK. Niosome: a mini review on its structure, properties, methods of preparation and medical applications. Journal of Chemical and Pharmaceutical Research, 2016; 8(10): 231-239.

[92] Pawar P, Sankhyan A. Recent trends in niosome as vesicular drug delivery system. Journal of Applied Pharmaceutical Science, 2012; 2(6): 20-32.

[93] Lalani R, Misra A, Amrutiya J, Patel H, Bhatt P, Patel V. Challenges in Dermal Delivery of Therapeutic Antimicrobial Protein and Peptides. Current Drug Metabolism. 2017; 18(5):426-36.

[94] Abdelkader H, Alani AWG and Alany RG. Recent advances in non-ionic surfactant vesicles (niosomes): self-assembly, fabrication, characterization, drug delivery applications and limitations. Drug Delivery, 2013; 21(2): 87-100