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Review Article

Niosome: A Promising Platform for Next Generation Cosmetic Application.

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ABSTRACT

Niosomes have gained attention as effective vesicular carriers in cosmetics due to their ability to improve penetration, stability, and controlled release of active ingredients. The stratum corneum acts as a key barrier, reducing the effectiveness of conventional formulations. Composed of non-ionic surfactants, cholesterol, and charge-inducing agents, niosomes enhance transdermal delivery and enable targeted action. This review covers their structure, composition, and preparation methods such as ethanol injection, ether injection, sonication, thin-film hydration, as well as newer techniques like ball milling and microfluidization. It also explains their mechanism of action, including modification of the skin barrier, increased hydration, and improved drug transport. Important characterization parameters like particle size, zeta potential, entrapment efficiency, and drug release are discussed. Additionally, their applications in cosmetics—such as anti-acne, skin whitening, sunscreen, anti-aging, lip care and hair care, and treatment of conditions like psoriasis and vitiligo—are highlighted. Despite challenges like stability and scale-up, advances in nanotechnology suggest strong potential for niosomes in future cosmeceutical development.

INTRODUCTION

The stratum corneum, which forms the outermost layer of the epidermis, acts as a robust barrier that restricts the entry and passage of active compounds through the skin. While smaller molecules are capable of penetrating this layer, larger ones (with a molecular weight above 500 Da) generally cannot cross it. Active ingredients may traverse the stratum corneum through transepidermal pathways—either between cells (intercellular) or through cells (intracellular)—as well as via transappendageal routes. However, the limited ability of many active substances to permeate the skin remains a significant challenge in the effectiveness of cosmetic formulations.

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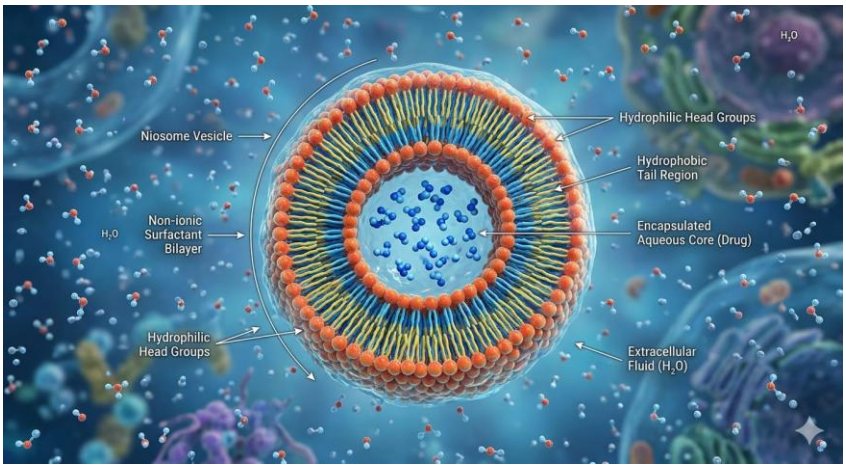
Over recent decades, extensive research in cosmetic chemistry has focused on developing and improving transdermal delivery systems to enhance skin penetration and enable controlled, targeted, and sustained release of active ingredients. These innovations have emerged alongside increasing consumer demand for more effective skincare products. Among these delivery systems, niosomes have gained considerable attention. Initially developed and patented by L'Oréal, niosomes are now widely utilized not only in cosmetics but also in the pharmaceutical and food sectors. This review outlines the potential of niosomes as carriers for targeted and prolonged delivery of cosmetic actives, highlighting their key physicochemical characteristics, production methods, and evidence of their effectiveness from both in vitro and in vivo studies. **[1]**

2.STRUCTURE AND COMPOSITION OF NIOSOME :

Conventional niosomal vesicles are typically composed of amphiphilic (nonionic) surfactants, such as Span 60. Their structural stability is generally supported by the addition of cholesterol along with a small amount of charged molecules, such as dicetyl phosphate, which help maintain vesicle integrity. The preparation of niosomes mainly involves three key components: cholesterol, nonionic surfactants, and a charged molecule. **[2]**



These components are essential for forming niosomes, which are vesicular systems used for drug encapsulation.

Non-ionic surfactants

This are use in the preparation of niosome offer several beneficial properties, including biodegradability, amphiphilic nature, low immunogenicity, and good biocompatibility. Unlike cationic, anionic, or amphoteric surfactants, non-ionic surfactants do not carry a charge, making them generally less toxic, more stable, and better tolerated. The characteristics of niosomes—such as their composition, size, surface charge, lamellarity, and the presence of additives—depend largely on the type and combination of surfactants used. Common examples include Tween (20, 40, 60, and 80) and Span (20, 40, 60, 80, and 85). Compared to other types of surfactants, non-ionic surfactants interact more gently with biological membranes, causing less irritation and hemolysis. They are widely used in the formulation of various physical, chemical, and biological systems. Their ability to form stable synthetic lipid bilayers makes them particularly valuable in drug delivery applications, often in combination with phospholipids. An important

feature of non-ionic surfactants is their capacity to inhibit P-glycoprotein, a property that can enhance the absorption and targeting of certain drugs. This includes steroids such as hydrocortisone, anticancer agents like daunorubicin, morusin, doxorubicin (DOX), and curcumin (CUR), cardiovascular drugs such as beta-blockers and digoxin, as well as HIV protease inhibitors like ritonavir. As a result, this surfactants can significantly improve the therapeutic effectiveness of such medications. The formation of bilayer vesicles is influenced by several factors, including the critical packing parameter (CPP), hydrophilic–lipophilic balance (HLB), chemical composition of the components, and the gel–liquid transition temperature. Surfactants with longer alkyl chains tend to show higher drug entrapment efficiency. In particular, Tween-based surfactants combined with cholesterol and possessing longer alkyl chains and larger hydrophilic groups demonstrate superior entrapment of water-soluble drugs. The HLB value plays a key role in determining how effectively a drug is incorporated into the vesicle, while the CPP depends on the size and volume of the hydrophobic portion relative to the polar head group. Overall, the properties of the surfactant strongly influence the in vivo behavior of niosomal drug delivery systems, as they affect critical parameters such as particle size, bilayer stability, drug release profile, and formulation consistency.

Cholesterol:

Cholesterol is a lipid-like steroid widely used in the preparation of niosomes and plays a crucial role in determining the rigidity, flexibility, and permeability of cellular membranes. Beyond its importance in niosome formation, it significantly affects their overall properties. When incorporated into the bilayer structure, cholesterol helps stabilize the membrane, reduces permeability, and generally enhances the drug entrapment efficiency of niosomes. It is also known to inhibit the transition of the niosomal bilayer from the gel phase to the liquid phase, thereby minimizing leakage of the encapsulated material. However, excessive amounts of cholesterol can negatively impact membrane permeability and hinder the penetration ability of niosomal vesicles, so it is typically used in limited quantities. Its presence also supports the rehydration of freeze-dried niosomes by improving permeability, encapsulation efficiency, and structural rigidity. Cholesterol contributes to vesicle stability when used alongside surfactants with low hydrophilic–lipophilic balance (HLB) values, and when the HLB exceeds 6, it facilitates the formation of bilayer vesicles. Additionally, increasing cholesterol content raises the viscosity of the formulation, which in turn enhances its rigidity.

Charge molecule:

Charged molecules are incorporated into niosomal formulations to prevent vesicle aggregation. These charge-inducing agents enhance stability by creating electrostatic repulsion between vesicles, thereby reducing the risk of coalescence. Common negatively charged additives include lipoamino acids, dihexadecyl phosphate, phosphatidic acid, and dicetyl phosphate (DCP). On the other hand, positively charged agents such as stearyl pyridinium chloride and stearyl amine (STR) are also used in niosome formulations. Typically, charge inducers are added in concentrations ranging from 2 to 5 mole percent. Maintaining this range is important, as higher concentrations may interfere with proper niosome formation. For effective vesicle development, the charged component is generally required to be present within approximately 2.5% to 5% of the total molar composition. **[3]**

Hydration Medium:

The choice of hydration medium plays a crucial role in the formation of niosomes. Phosphate buffer saline is widely preferred for this purpose. The pH of the hydration medium is adjusted based on how well the encapsulated substance dissolves, ensuring optimal conditions for its stability and incorporation. **[3]**

3. MERITS:[4]

- Compared to phospholipid molecules used in liposome formulations, the surfactants used in the formation of niosomes are more stable
- Niosome improve penetration through skin
- Niosomes possess longer shelf-life than liposomes and most other nanocarrier systems Unlike liposomes, they are stable at room temperature and less susceptible to light
- Niosome can be administered by various route like oral , Intravenous , topically

4.DEMERITS : [5]

- May show signs of drug fusion, leaching, or hydrolysis, which would shorten its shelf life.
- The drug loading capacity is insufficient
- Specialized equipment is needed for manufacturing
- The drug leaks when entrapped

5.Method Of Preparation Of Niosome:

Ethanol Injection Method:[6]

This method offers a quick and straightforward way to prepare small unilamellar vesicles. It involves injecting a lipid solution dissolved in ethanol into an aqueous phase, which leads to the spontaneous formation of vesicles. To improve lipid solubility and increase encapsulation efficiency, co-solvents like isopropanol can be added alongside ethanol. Adjusting factors such as the injection rate and temperature allows control over vesicle size and helps reduce aggregation, adding flexibility to the process. Overall, the technique is cost-effective, simple to implement, scalable, and does not rely on complex equipment. Additionally, the niosomes produced using this approach tend to be smaller than those formed through thin film hydration or microfluidics methods.

Ether Injection Method :[6]

The ether injection method, first described by Deamer and Bangham in 1976, involves dissolving nonionic surfactants and other components in diethyl ether and then injecting this solution into an aqueous phase maintained at around 60–65 °C. The temperature difference between the organic and aqueous phases promotes the evaporation of the solvent, leading to vesicle formation. This technique is capable of producing relatively inexpensive large unilamellar niosomes. However, one limitation is that small amounts of ether may remain in the final vesicle suspension, and removing it completely can be challenging. In this method, niosomes form as the ether solution of lipids is introduced into the heated aqueous phase, with gradual solvent evaporation allowing bilayer structures to develop. Because lipophilic drugs dissolve well in ether, this approach is particularly suitable for their incorporation. Any residual ether can be further reduced by evaporation under decreased pressure, which enhances the safety of the formulation for pharmaceutical use.

Bubble Method [6]

The bubbling method for preparing niosomes involves using a three-necked round-bottom flask

placed in a water bath to control temperature. Each neck of the flask is fitted with a different component: a water-cooled reflux system, a thermometer, and a nitrogen gas inlet. At around 70 °C, cholesterol and surfactants are dispersed in a buffer solution (pH 7.4), briefly mixed using a high-shear homogenizer for about 15 seconds, and then exposed to a stream of nitrogen gas. This bubbling process leads to the formation of niosomes. One of the key advantages of this method is that it does not require any organic solvents and can be completed in a single step, making it more environmentally friendly. However, most of the available research on this technique is limited and largely based on a study from 1989, which makes it difficult to fully understand and optimize the process. The method works by bubbling nitrogen gas through an aqueous mixture of surfactants and cholesterol, forming vesicles in the process. Factors such as bubble size and gas pressure play an important role in determining vesicle formation and how efficiently compounds are encapsulated. While the technique shows potential, especially for encapsulating volatile substances, its large-scale application remains challenging due to the lack of extensive research

Sonication Method : [6]

The sonication method is considered a green and eco-friendly approach for preparing niosomes. It is straightforward, cost-effective, and avoids the use of organic solvents. In this process, the aqueous phase containing the drug is mixed with surfactants and cholesterol, then subjected to sonication for a few minutes at around 60 °C using a titanium probe sonicator. The resulting niosomes are typically collected either by filtration through filter paper or by freeze-drying. A key benefit of this technique is that it produces very small niosomes without relying on organic solvents. However, based on these conditions, it is not well suited for drugs that are poorly soluble in water. Additionally, the method may lead to the formation of small multilamellar vesicles.

Novel Ball Milling Method :[6]

The ball milling (BM) method is an emerging and promising approach for improving both the quality and efficiency of niosome production. This technique uses a container filled with small spherical balls during the manufacturing process, which helps in forming niosomes with precise and controllable sizes and shapes. As a result, it becomes easier to tailor them for specific drug release requirements. One of the key advantages of the BM method is its ability to overcome the limitations of conventional niosome preparation techniques. It offers better control over particle size distribution and improves encapsulation efficiency, ultimately leading to a more reliable and effective drug delivery system. In this process, the drug is first dissolved in deionized water (or another suitable solvent) in one container. In a separate container, surfactants such as Span and cholesterol are also dissolved. These two solutions are then combined and transferred into a milling chamber containing multiple small balls. When the chamber rotates, mechanical forces are generated, causing the particles to collide, break down, and compress. This action promotes the formation of niosomes. The mechanical energy applied during ball milling ensures that surfactants and lipids are evenly distributed, which enhances the stability of the final formulation. Using smaller milling balls and increasing the rotation speed can further improve particle uniformity. Additionally, integrating microfluidic post-processing can help fine-tune vesicle size for targeted drug delivery, making the technique highly adaptable and scalable. Compared to traditional methods such as thin film hydration—which often produces larger,

less uniform particles—or reverse phase evaporation, which involves more complex steps, the ball milling approach is simpler and more reproducible. It allows better control over particle size through adjustments in rotation speed and also improves encapsulation efficiency, making it a highly effective alternative for niosome preparation.

Microfludization : [7]

Microfluidization is a relatively recent technique used to produce unilamellar vesicles with a well-defined and consistent size range. It works on the submerged jet principle, where two streams of fluid are forced through microchannels at very high speeds—reaching up to 1700 feet per second—inside a specially designed interaction chamber. Within this chamber, the streams collide as thin liquid sheets along a shared front, creating the conditions necessary for niosome formation. This setup ensures that the applied energy is concentrated precisely in the interaction zone, which leads to better control over the process. As a result, the technique produces smaller, more uniform vesicles with high reproducibility. These advantages make microfluidization a strong candidate for large-scale and commercial production.

Thin film hydration : [7]

In this method, vesicle-forming components such as cholesterol and surfactants are first dissolved in a volatile organic solvent like chloroform or diethyl ether in a round-bottom flask. A rotary evaporator is then used to remove the solvent at around room temperature, leaving behind a thin, dry film of the mixture on the inner wall of the flask. This film is then rehydrated by adding water with gentle agitation at elevated temperatures, typically between 50 and 60 °C. As a result of this process, multilamellar niosomes are formed. The size of these vesicles can be reduced by hydrating the lipid mixture at a temperature above the phase transition temperature of the surfactant and applying vortexing during hydration. Overall, vesicles produced using this hand-shaking method tend to be larger in size, usually ranging from 0.35 to 13 µm, compared to those prepared by the ether injection method, which typically fall within the 50–100 nm range.

6.Mechanism Of Action Of Niosome: [8]

The ability of niosomes to enhance drug transport across the skin cannot be attributed to a single mechanism; rather, it involves several complementary processes:

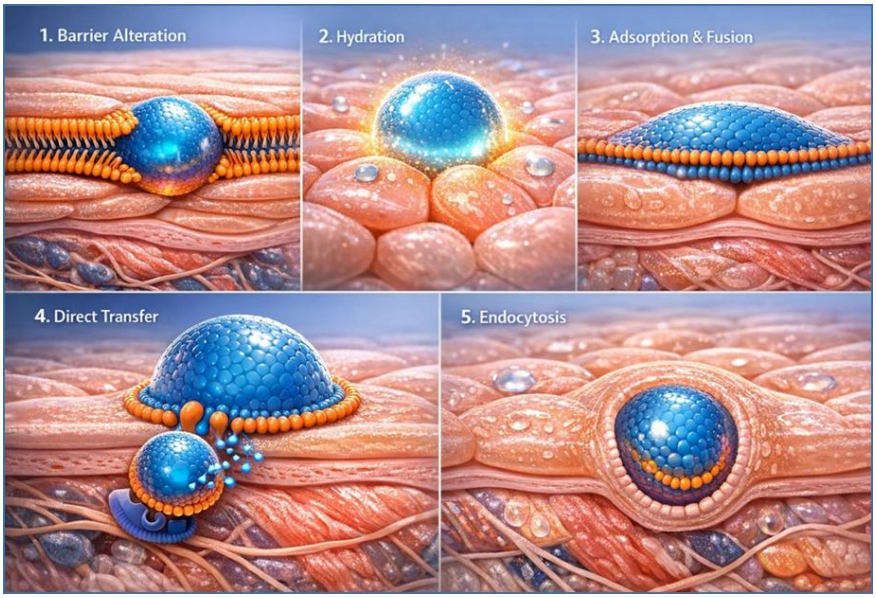
Alteration of the skin barrier: Niosomes can temporarily disturb the lipid arrangement in the stratum corneum, thereby modifying its barrier properties.

Reduction in water loss: They help increase hydration in the stratum corneum by limiting transepidermal water loss, which in turn softens and loosens the skin structure.

Adsorption and fusion: Niosomes may attach to the skin surface, creating a high thermodynamic activity gradient that promotes drug penetration.

Cell surface interaction and direct transfer: Through physical interactions or receptor-mediated processes, niosomes can adhere to cell membranes and deliver drugs directly, sometimes by fusing with the membrane without being internalized.

Endocytosis: In some cases, skin cells take up niosomes via endocytosis. Once inside, lysosomal enzymes break down the vesicle, releasing the encapsulated drug into the surrounding medium.



Niosomes can disrupt the structure of the stratum corneum, making it more relaxed and permeable, which enhances drug penetration through the skin. The non-ionic surfactants used in niosomal formulations themselves can act as effective skin permeation enhancers. In addition, the very small particle size of niosomes further improves the bioavailability of drugs delivered through the skin. Research has shown that niosomes loaded with minoxidil significantly enhance both skin penetration and bioavailability compared to conventional topical formulations. Studies have also indicated that factors such as particle size and the behavior of surfactants play a major role in determining the extent of drug permeation and overall bioavailability. Similarly, niosomes containing 5-aminolevulinic acid (ALA) have been reported to greatly improve drug penetration compared to simple aqueous suspensions. Niosomes can act as nanocarriers for a wide range of therapeutic agents, including both small chemical drugs and larger molecules like peptides and proteins. Common surfactants such as Spans and Tweens are widely used in drug-loaded niosomes, while diacyl glycerides and polyoxyethylene ethers are more often used in systems designed for peptide and protein delivery. These components also contribute to enhancing skin permeation. The choice of non-ionic surfactant and the amount of cholesterol included in the formulation are key factors in transdermal drug delivery. Studies suggest that Tweens generally provide better skin permeation than Spans, while lower cholesterol levels can also enhance drug transport through niosomes. Another important factor is vesicle membrane fluidity, which strongly influences the efficiency of transdermal delivery. Essential oils, particularly terpenes, are also important additives in niosomal formulations as they can improve penetration by disrupting the structure of the stratum corneum. They also increase vesicle flexibility and fluidity, which further enhances drug delivery through the skin. For example, studies have shown that incorporating essential oils into felodipine-loaded niosomes significantly improves drug permeation, with the effect depending on both the type and concentration of the oils used. Oils such as lemon, clove, and eucalyptus have been found to markedly enhance transdermal delivery compared to niosomes without these additives. **[9]**

7.CHARACTERIZATION OF NIOSOME :

Particle Size : A Zeta sizer is one of the most commonly used instruments for analysing the size distribution of niosomes. It works based on a technique known as Dynamic Light Scattering (also called photon correlation spectroscopy). This method detects fluctuations in scattered light that occur due to the Brownian motion of particles in suspension.Through DLS, it is possible to determine the average particle size, the distribution of sizes, and the polydispersity index of niosomes. **[10]**

Particle Morphology : TEM permits direct imaging of niosomes at high resolution. By taking images of niosomes, it determines the size by measuring dimensions of individual vesicles. TEM offers complete image.

Atomic Force Microscopy (AFM) is a high-resolution imaging method used to study the surface structure and morphology of niosomes. It provides detailed nanoscale topographical data and can also help visualize the three-dimensional shape of niosomes. **[10]**

Fourier Transform Infrared (FTIR) spectroscopy is used to identify any possible incompatibilities between lipids, surfactants, bioactive compounds, or other chemicals involved in formulation development. First, FTIR spectra are recorded for each individual excipient, and then for a combined mixture of all the formulation components. Any variation observed in the fingerprint region of the active compound indicates a potential incompatibility. **[10]**

Zeta potential : It is used to measure the surface charge of niosomes, which can be determined using instruments such as a Zeta sizer and DLS (Dynamic Light Scattering) equipment. The surface charge plays an important role in defining the properties of niosomes, as charged vesicles are generally more stable and less likely to aggregate compared to those without charge. **[2]**

Entrapement Efficiency : The evaluation of drug loading and encapsulation efficiency in niosomal dispersions involves first separating the unentrapped drug from the formulation. After preparing the niosomal dispersion, the free drug is removed using techniques such as dialysis, centrifugation, or gel filtration, as described earlier. To determine the amount of drug encapsulated within the niosomes, the vesicles are completely broken down using agents like 50% n-propanol or 0.1% Triton X-100. The obtained solution is then subjected to a suitable analytical drug assay. Encapsulation efficiency is expressed as a percentage and indicates the proportion of drug successfully trapped within the niosomes. Methods such as centrifugation, dialysis, and gel chromatography are commonly used to separate unencapsulated drug from the formulation. After this step, the drug retained inside the niosomes can be released by disrupting the vesicular structure. **[2]**

Drug release: Drug release kinetics from niosomes describes the rate and extent at which a compound is released over a period of time. This can be evaluated by monitoring the amount of drug released from the niosomal system at different time intervals using techniques such as UV–Visible spectroscopy or HPLC. After obtaining the release data, the rate constant is calculated and the release profile is analysed to determine whether it follows zero-order, first-order, Higuchi's square root model, Hixson–Crowell cube root model, or other kinetic models. **[10]**

Stability Study :

Stability studies of niosomes are carried out by storing the formulations under two different conditions, usually at 4 ± 1 °C and 25 ± 2 °C. The

formulation is then evaluated for changes in vesicle size, shape, and the number of vesicles per cubic millimetre before storage and after a 30-day period. Residual drug content is also assessed at 15-day and 30-day intervals. Vesicle size is observed using a light microscope, while a haemocytometer is used to count the number of vesicles per cubic millimetre. In general, stability assessment involves monitoring average vesicle size, size distribution, and encapsulation efficiency over prolonged storage at different temperatures for several months. Samples are taken at regular intervals to determine how much drug remains entrapped within the niosomes. The percentage of drug retention is then analysed using UV spectroscopy or HPLC methods. **[2]**

8.APPLICATION OF NIOSOME :

Anti acne formulation :

Dapsone-loaded niosomes prepared using the thin film hydration method demonstrated that niosomal systems can offer sustained and extended drug delivery, improving overall clinical effectiveness. The study also showed that dapsone niosomes can be used as a once-daily topical treatment for mild to moderate acne vulgaris, leading to early as well as continued clinical improvement . **[11]** Doxycycline is a second-generation bacteriostatic antibiotic belonging to the tetracycline class. In this study, doxycycline-loaded niosomes were prepared using the thin film hydration method. The formulation showed improved skin permeation compared to the free drug. The antibacterial activity of the optimized niosomal formulation, drug-free niosomes, and free drug solution was evaluated against the main acne-causing bacteria, *Propionibacterium acnes* and *Staphylococcus epidermidis*. The results demonstrated that doxycycline-loaded niosomes have promising potential. **[12]** Azelic acid-loaded niosomes were also prepared using the thin film hydration method. The study demonstrates the successful development of a niosomal gel designed for the sustained release of azelaic acid, meeting the need for an effective and better-tolerated anti-acne therapy. The thin film hydration technique was found to be an effective method for incorporating the hydrophobic azelaic acid into niosomes with high entrapment efficiency. **[13]**

Skin whitening Formulation :

N-acetyl glucosamine (NAG) is well recognized as a precursor of hyaluronic acid. It is a mild skin-lightening agent that offers good stability and can be effectively used in topical formulations. The sustained drug release and enhanced permeation through rat skin observed with NAG-loaded niosomes suggest their potential for efficient topical delivery. This was further supported by the increased amount of NAG retained or localized within the skin. Moreover, the reduced systemic absorption associated with topical NAG niosomes may help in minimizing side effects. **[14]** Glutathione is an antioxidant made up of three amino acids—glutamate, cysteine, and glycine. It is widely used as a skin-lightening agent due to its relatively rapid action. It works by inhibiting the enzyme tyrosinase through three main mechanisms: by chelating the copper ion at its active site via the thiol group, by disrupting the transport of tyrosinase to premelanosomes where melanin is produced, and by indirectly suppressing tyrosinase activity through its antioxidant properties, as its free radical scavenging action prevents peroxide-induced activation of the enzyme. In the glutathione-treated right side, the hemi-MASI score after treatment showed a decrease, but it was not significantly different from the baseline. In contrast, the right side treated with glutathione-loaded niosomal gel showed a significant reduction in the hemi-MASI score. Overall, there was a highly significant difference

in the percentage reduction of hemi-MASI scores between the right sides of both treatment groups. **[15]**

Sunscreen Formulation :

Anthocyanins derived from purple waxy corn act as natural UV protectants and help reduce oxidative damage in plant tissues. This property makes them a promising source for developing UV-protective ingredients for cosmetic and skincare products. The study showed that optimized niosomal formulations containing these compounds demonstrated good physicochemical stability, sustained drug release, and strong UVB protection, along with anti-tyrosinase and anti-melanogenic activities. These results indicate that such formulations may act as effective and biocompatible delivery systems for natural cosmeceutical applications aimed at managing hyperpigmentation and providing UV protection. **[16]** Morin, a member of the flavanol family, is widely found in plants, with particularly high levels in sources such as onion, mulberry (Morus), and seaweed. Previous research has shown that morin can enhance the expression of antioxidant enzymes, helping the body's defense system respond more effectively to oxidative stress caused by UV radiation and heat exposure. It also exhibits tyrosinase inhibitory activity. Niosomes loaded with morin have demonstrated strong anti-aging effects, including a reduction in melanin production through tyrosinase inhibition and effective scavenging of intracellular reactive oxygen species (ROS). In addition, the formulated cream provided good protection against UV radiation, with an SPF value greater than 30. Overall, the developed morin-loaded niosomes showed promising anti-aging benefits—such as antioxidant and anti-spotting effects—along with significant sun-protective properties. **[17]**

Niosome in treatment of psoriasis :

Niosomes are a promising delivery system for topical treatments, as they can improve both the effectiveness and safety of products used in psoriasis therapy. Encapsulating drugs such as dithranol and methotrexate within niosomal formulations has been shown to enhance their skin penetration while also reducing unwanted side effects. Similarly, a niosomal urea gel prepared with Span 60 demonstrated better drug diffusion through the skin and resulted in a marked reduction in the severity of psoriatic lesions compared to conventional urea gel. Overall, these results indicate that niosomes—especially when incorporated into chitosan gel—could serve as a useful supportive approach in psoriasis management, improving treatment outcomes and patient adherence. **[18]** Psoriasis is an autoimmune skin condition marked by rashes, skin lesions, thickened skin (hyperkeratosis), and sometimes pustular formations. In this study, niosomes were formulated using the thin film hydration method. The optimized batch of cyclosporine-loaded niosomes demonstrated enhanced skin penetration and better drug deposition, making them more effective for the treatment of psoriasis. **[19]**

Niosome in vitilgo :

Vitiligo is a skin condition that leads to loss of pigmentation, often causing noticeable white patches that can strongly affect a person's quality of life. Traditional topical treatments frequently show limited effectiveness and may cause side effects, which can reduce patient adherence. In this context, advanced dermal drug delivery systems like elastic cationic niosomes are gaining attention as a promising alternative. These carriers have shown potential in gene therapy approaches for vitiligo by efficiently delivering genes involved in melanin production. Studies indicate that elastic cationic niosomes are more effective than conventional non-elastic niosomes and liposomes

in transporting tyrosinase-encoding plasmids as well as luciferase plasmids. This suggests they could serve as an efficient topical gene delivery platform for treating vitiligo, offering a promising strategy that does not require any additional specialized equipment. **[18]**

Niosome in lip care :

Herpes labialis, commonly known as cold sores, affects the skin and mucous membranes, especially around the lips, and is typically marked by a burning or tingling sensation before and during the outbreak. Acyclovir is widely used as an antiviral treatment for this condition. In this context, a lip rouge formulated with acyclovir-loaded niosomes demonstrated enhanced drug penetration compared to conventional formulations. This suggests that the developed lip rouge not only offers improved physicochemical characteristics and more effective drug release than marketed products, but also provides an attractive cosmetic finish with appealing colour and flavour. As a result, it combines therapeutic effectiveness with user-friendly application, potentially improving both treatment outcomes and patient acceptance. **[20]**

Niosome in hair care :

Cetirizine, a second-generation antihistamine, has recently been investigated for its potential role in treating alopecia. In this approach, cetirizine-loaded niosomes were prepared using the thin film hydration method. When compared to the plain drug, the niosomal formulation showed a more sustained release profile. These findings suggest that niosomes could serve as an effective carrier system for delivering drugs through the skin in the management of alopecia. **[21]** Minoxidil-loaded niosomes were developed using the ethanol injection method. Compared to a standard minoxidil gel, the niosomal formulation demonstrated significantly higher skin retention—up to eight times greater **[22]** Deer antler velvet (DAV) is a natural extract known to promote the growth of skin and hair cells. When incorporated into niosomes and formulated into an MS serum, it demonstrated markedly improved penetration of macromolecular proteins through the skin, reaching deeper layers effectively. Application of this serum on the human scalp for 14–30 days led to noticeable improvements in hair growth as well as an increase in melanin content. **[23]** A microneedle system integrated with niosomes has been developed to deliver ketoconazole directly to targeted areas for the treatment of androgenic alopecia. This approach helps bypass the limitations of conventional drug delivery methods and enables more precise, localized delivery of the drug. **[24]** Kopexil works through a mechanism similar to minoxidil but is associated with fewer side effects. However, its effectiveness is limited by poor absorption through the stratum corneum due to its hydrophilic nature. By the end of the study, hair density had increased by 57.6 ± 3.7% in the niosomal kopexil group and 25.6 ± 4.2% in the niosomal minoxidil group ($P < 0.001$). In terms of patient satisfaction, a significantly higher proportion of participants reported being highly satisfied with niosomal kopexil (50%) compared to those using niosomal minoxidil (6.7%). **[25]**

CONCLUSION:

The future of niosome-based drug delivery in cosmetics looks very promising, driven by rapid progress in nanotechnology and the growing demand for more effective cosmeceutical products. Niosomes provide several important benefits, including better skin penetration, controlled release of active ingredients, and improved stability. Current research is increasingly focused on developing hybrid vesicular systems, designing personalized

cosmetic formulations, and incorporating natural bioactive compounds. Despite these advancements, certain challenges—such as scaling up production, meeting regulatory requirements, and ensuring long-term safety—still need to be addressed before these systems can be widely commercialized. With ongoing innovation, niosomes are likely to play a significant role in the development of next-generation cosmetic and dermatological formulations.

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