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Review Article

Transferosomes: A Next-Generation Ultra-Deformable Vesicular System Structure, Mechanism, and Future Prospects

Sameer Shafi[1], Shivlila Swami*[1],Pranita Waghmare [2], Ankita Gadhave[3], Madhuri Damane[4].

Shivlingeshwar College of Pharmacy, Almala, Latur, Maharastra, India

A B S T R A C T

Targeted Drug Delivery Systems (TDDS), also known as smart drug delivery systems, are designed to increase drug concentration at specific target sites while minimizing systemic exposure. Among various vesicular carriers, transferosomes have emerged as highly effective for dermal and transdermal drug delivery. Transferosomes are ultra-deformable vesicles composed of phospholipids and edge activators that enable them to penetrate the stratum corneum through narrow pores, driven by the osmotic gradient between skin layers. Their unique elasticity and hydration-driven mobility facilitate enhanced permeation and controlled drug release.Transferosomes can encapsulate both hydrophilic and lipophilic drugs, providing high entrapment efficiency, biocompatibility, and biodegradability. They improve bioavailability, reduce first-pass metabolism, and minimize toxicity. However, high production costs, formulation instability, and phospholipid purity issues remain significant challenges.Several preparation techniques, including thin-film hydration, rotary evaporation, and ethanol injection, yield vesicles with desirable size and stability. Characterization involves determining entrapment efficiency, vesicle morphology, zeta potential, in vitro release, and skin permeation. Transferosomes have been successfully employed in delivering anticancer agents, proteins, peptides, insulin, corticosteroids, and antifungal drugs with enhanced therapeutic outcomes.Despite certain drawbacks, transferosomes represent a promising and versatile carrier for non-invasive and site-specific drug delivery. Their superior permeability, controlled release, and compatibility with both synthetic and natural drugs make them a significant advancement in transdermal nanocarrier systems.

Keywords: Novel drug delivery systems, Transferosomes, Transdermal drug delivery, Targeted drug delivery,etc.

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*Address for Correspondence:
Dr. Sameer Shafi, Professor and Head Department of Pharmaceutics, Shivlingeshwar College of Pharmacy, Almala, Latur.

INTRODUCTION:

Targeted Drug Delivery Systems (TDDS), also referred to assmart drug delivery systems,are designed to increase the concentration of a drug at a specific target site compared to other organs or tissues of the body [2]. Among various vesicular drug delivery systems, transferosomeshave emerged as one of the most promising carriers. The concept of transferosomes was first introduced by Gregor Cevc in 1991, and the term was later trademarked by the IDEA AG Company, Germany. The word “transferosome” is derived from the Latin term transferre(to carry across) and the Greek word soma(body), collectively meaning “carrying body” [7].Transferosomes represent an advanced form of vesicular drug delivery system suitable for both dermal and transdermal administration**.** While traditional carriers such as liposomes and niosomeshave been widely used, transferosomes offer distinct advantages in enhancing drug penetration through the skin [13]. As nanoparticulate drug carriers, they provide several benefits, including high stability, large drug-loading capacity, and the ability to encapsulate both hydrophilic and lipophilic agents. They can also be administered through multiple routes, such as oral or inhalation pathways [14].

Moreover, transferosomes can act as drug depots**,** facilitating controlled and sustained release. Their superior performance is attributed to the osmotic gradient between the outer and inner layers of the stratum corneum**,** which drives their penetration [15]. The effectiveness of transferosomes largely depends on the type of edge activator and theratio of phospholipid to edge activator, as these parameters influence vesicle size, entrapment efficiency, and skin permeation [16]. These systems are particularly beneficial for delivering

poorly soluble drugs and phytoconstituents from herbal sources, which generally face challenges in crossing biological barriers such as the epidermis [16].

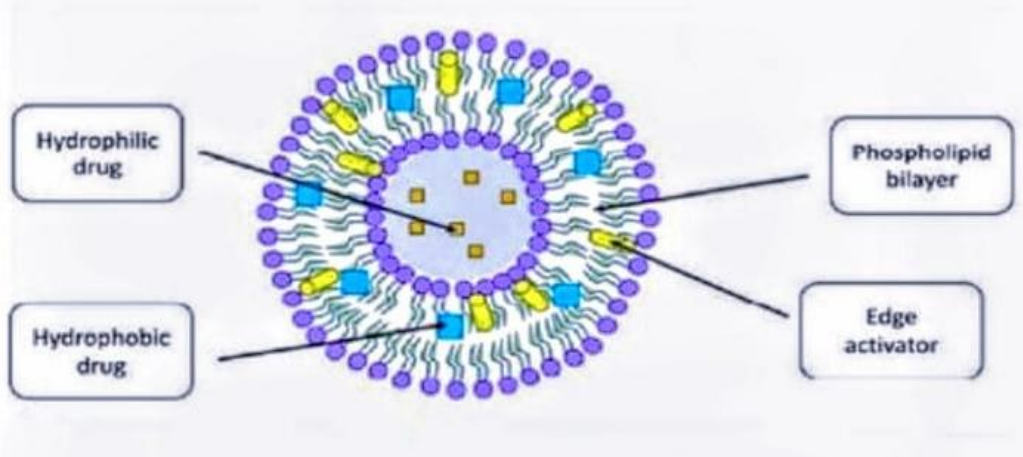

Figure.1 Structure of Transferosomes

Transferosomes V/S Other Carrier System:

Transferosomes, niosomes, proniosomes, liposomes, ethosomes, and electrosomes are all types of vesicular drug delivery systems that have gained attention in the field of nanotechnology10-13. Among these, transferosomes are a promising option for transdermal drug delivery due to their ability to penetrate through the skin pores, encapsulate both hydrophilic and lipophilic molecules, prolong the drug's existence in the systemic circulation, target organs and tissues, and reduce drug toxicity while increasing bioavailability [19].

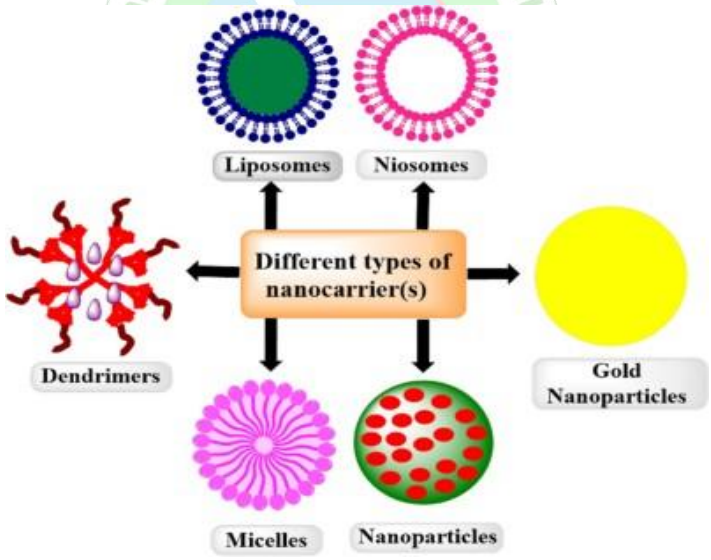

Figure.2 Different types of Nanocarrier

Phytochemical Delivery Through Transferosome (Phytosome) :

Transferosomes are typically applied topically without any occlusive covering and have been shown to effectively penetrate the stratum corneum, particularly its lipid lamellar regions, resulting in enhanced skin hydration (Benson, 2006). The evaporation of water from the skin surface due to body heat creates an osmotic gradient**,** which serves as the driving force for the movement of the drug from the site of application to deeper skin layers or into systemic circulation, depending on the therapeutic goal. In addition to facilitating drug transport, transferosomes also contribute to improving skin health by maintaining enzyme balance, increasing hydration, and supporting the structural integrity of collagen. However, many polyphenolic compounds exhibit limited lipid solubility and poor absorption because of their hydrophilic nature, which restricts their biological activity in vivo. Interestingly, severalflavonoid molecules demonstrate strong interactions with the phospholipid components of phytosomes**,** thereby enhancing their stability, solubility, and therapeutic potential [9].

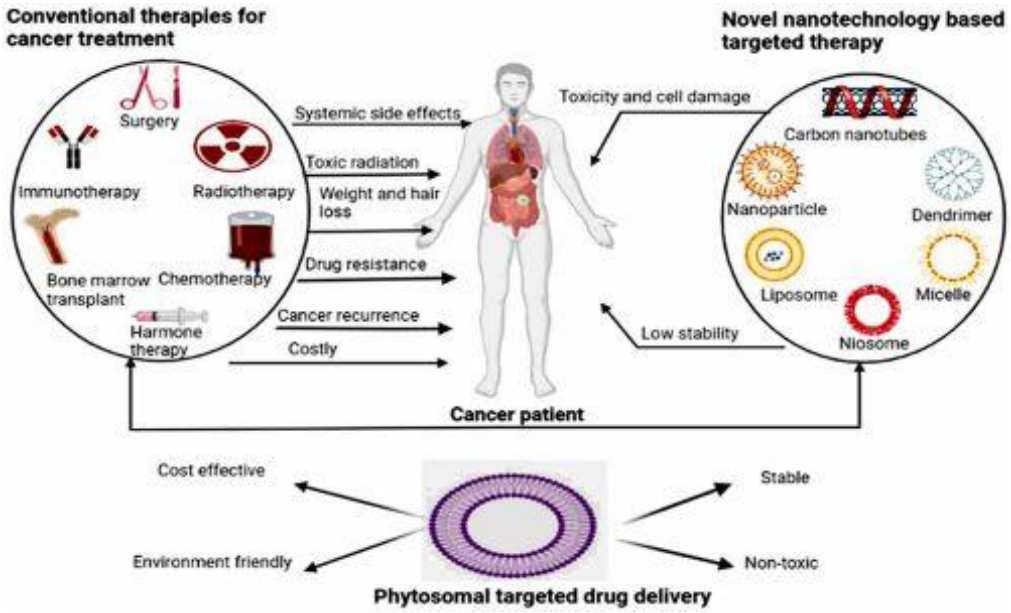

Figure.3: Phytochemical delivery through Transferosomes

Advantages of Transferosomes:-

- Transferosomes can enhance skin permeation better than conventional drug solutions, allowing for more efficient transdermal drug delivery [19].
- Transfersomes have been used as carriers for different therapeutic agents, including proteins, insulin [20].
- Transferosomes are ultra-deformable vesicles that can squeeze themselves through narrow pores smaller than their size, making them a useful drug delivery system for poorly soluble drugs [19].
- Preventing first-pass metabolism, a significant disadvantage in oral medication delivery, and maximizing the drug's bioavailability [21].
- Reduce the drug's unwanted side effects and shield it from metabolic breakdown; additionally, short half-life medications are useful [21].
- Drug release rate and the deposition to the target site can be adjusted by modification of vesicular composition or surface property of transfersome membrane [22].
- An equivalent therapeutic effect can be achieved with a lower daily dose of the drug than necessary [22].
- Self-administration is possible with these systems [19].

Disadvantages of Transferosomes:-

- High cost of the product is a major drawback for the wide acceptance of this transfersomes [22].
- Transferosomes may have limited drug loading capacity and may not be suitable for all types of drugs [19].
- Purity of natural phospholipids is another criterion that poses problems in using transfersomes as drug delivery vehicles [22].
- Barrier role of the skin changes with age and is different from person to person and from one site to another site of the skin on the same person [21].
- It offers gradual therapeutic benefits for hydrophilic structures on the skin [19].
- Transfersomes, by virtue of their enhanced elasticity in contrast to standard liposomes, are more amenable to the transport of therapeutic agents across the human skin [20].
- Difficulty in achieving phospholipid purity and the high cost of formulation due to the use of expensive equipment and raw materials [19].
- Drugs that require high blood levels cannot be administered [22].
- They are sensitive to temperature and pH changes, which can affect their stability and drug release properties [19].

Silent Features of Transfersomes:-

Transfersomes Possess Several Distinctive Features That Make Them A Promising Option For Drug Delivery. These Features Include:

a) Transfersomes exhibit high deformability, enabling them to effectively penetrate narrow constrictions and maintain the integrity of the vesicles.

b) Wide Range of Drug Solubility: The infrastructure of transfersomes consists of hydrophobic and hydrophilic moieties, enabling them to accommodate drug molecules with varying solubilities. They can effectively carry both hydrophilic and lipophilic drugs.

c) High Entrapment Efficiency: Transfersomes exhibit high entrapment efficiency, particularly for lipophilic drugs, with rates reaching close to 90%. This ensures that a significant amount of the encapsulated drug is retained within the vesicles.

d) Biocompatibility and Biodegradability: Transfersomes are composed of natural phospholipids, similar to liposomes, making them biocompatible and biodegradable. This enhances their safety profile and minimizes potential adverse effects [18].

Factors Affecting Transferosomal Delivery:-

a) Biological factors

i. *Skin age-* Children are more sensitive to the absorption of toxins to skin; the young age of skin is more permeable than the old age skin

ii. *Condition of skin-* Skin condition is altered by the diseased state of the patient. Furthermore acids, alkalis, solvents like methanol and chloroform injures the skin cells and elevates penetration

iii. *Metabolism of skin-* Skin metabolizes drugs, hormones, steroids and some of the carcinogens. Thus, metabolism of the skin predicts the effectiveness of drug permeated into the skin

iv. *Skin site-* Nature of SC, thickness of skin, keratins and appendages vary from one site to another site

b) Physicochemical factors

i. *Drug concentration-* Flux is proportionate to the concentration gradient through the barrier. Thus, concentration gradient will be greater when the drug concentration is more across the barrier

ii. *Skin hydration-* Hydration is an important component in increasing the skin permeability. Permeability of the skin increases in contact with water. Hence, humectants are used in formulation of transdermal delivery

iii. *Temperature and pH-* The permeation of the drug increases with the variation in temperature. The temperature decreases as the diffusion coefficient decreases. The portion of unionized drug determines the drug concentration in skin

iv. *Partition coefficient-* For highly lipophilic molecules (log K > 3) and for the molecules with intermediate partition coefficient (log K 1 to 3) the intercellular route is the pathway and furthermore ability to partition out of the SC into aqueous region via epidermal tissues, hydrophilic molecules (log K < 1) the transcellular route are likely to dominate [23].

Composition of Transferosomes

Transferosomes consist of phospholipids like phosphatidylcholine which is an amphipathic component and a lipid bilayer constituent known as edge activator which leads to the arrangement of the vesicle.

Phospholipids-

- The main ingredient in the vesicles are composed of phosphatidylcholine like soy phosphatidylcholine, egg phosphatidylcholine etc. are the vesicle forming elements that makes the lipid bilayer.
- 10-25% of surfactant and different solvents like methanol, ethanol comprising of saline phosphate buffer (pH 6.5 -7) and dyes like Nile red and Rhodamine are utilized for flexibility
- Phosphatidylcholine is a fatty composition which can be obtained from both human and vegetable origin, and is primarily an unsaturated fatty acid. These unsaturated fatty acids are mainly linoleic acid up to 70% of the total fatty acids.

Edge activators (EA)-

- Edge activator is a biocompatible surfactant which is also known as “bilayer softening compound”. Edge activators increase lipid bilayer permeability and flexibility.
- Edge activator mainly consists of the nonionic nature of single chain surfactant which destabilizes the lipid bilayer. Therefore, increasing its flexibility and elasticity. By adding suitable surfactant in appropriate ratio, flexibility of transferosomes are modified.
- Surfactants such as Tweens like Tween 20, Tween 60, Tween 80
- Spans like Span 60, Span 65 and Span 80, sodium cholates, sodium deoxy chocolate and dipotassium glycyrrhizinate are used to increase bilayer flexibility and permeability in transferosome preparations [7].

Mechanism of Transferosomes

When applied under suitable conditions, transferosomes are capable of transporting approximately 0.1 mg of lipid per square centimeter per hour through intact skin—a rate significantly higher than that achieved by simple transdermal diffusion. This enhanced permeation is primarily driven by the transdermal osmotic gradient. The skin’s natural barrier minimizes water loss, maintaining about 75% water content in the epidermis and only 15% in the outer stratum corneum. Polar lipids present in the skin attract water molecules due to interactions between their hydrophilic regions and surrounding water.When a transferosomal suspension is applied to the skin, partial dehydration occurs, prompting the lipid vesicles to respond to the osmotic imbalance by migrating across the skin layers to avoid complete drying. Their high deformability, imparted by surfactants and hydration-promoting components, enables them to pass through narrow pores within the skin.Transferosomes overcome the skin penetration barrier by compressing and navigating through the lipid layers of the stratum corneum (SC). Two major mechanisms have been proposed for their enhanced drug delivery:

1. As drug carriers, transferosomes penetrate the skin while remaining structurally intact, transporting the encapsulated drug.
2. As penetration enhancers, they temporarily disrupt the organized intercellular lipids within the SC, facilitating deeper movement of drug molecules through the skin.

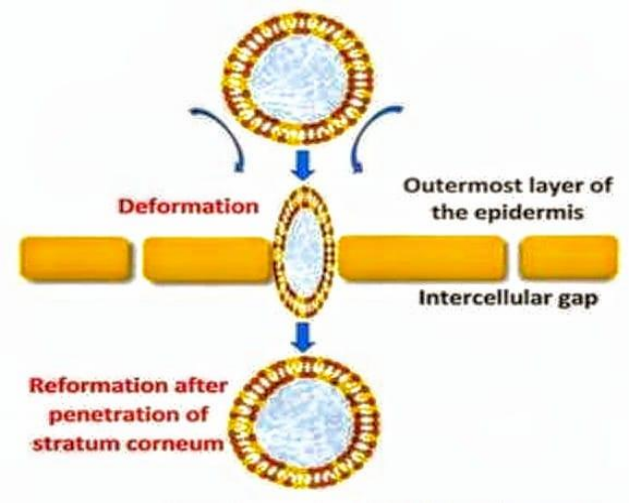

Figure 4 Mechanisms of Transferosomes

METHODS TO PREPARE TRANSFEROSOMES

1. Thin film hydration method

It is employed for the preparation of transfersomes which are comprised of three steps:

1. A thin film is prepared from the mixture of phospholipids and surfactant by dissolving in volatile organic solvent (chloroform-methanol). Organic solvent is then evaporated above the lipid transition temperature (room temp. for pure PC vesicles, or 500C for dipalmitoylphosphatidylcholine) using a rotary evaporator. Final traces of solvent were removed under vacuum overnight.
2. A prepared thin film is hydrated with buffer (pH 6.5) by rotation at 60 rpm for 1 hr at the corresponding temperature. The resulting vesicles were swollen for 2 hrs at room temperature.
3. To prepare small vesicles, the resulting vesicles were sonicated at room temperature or 50°C for 30 min. using a bath sonicator or probe sonicated at 4°C for 30 min. The sonicated vesicles were homogenized by manual extrusion 10 times through a sandwich of 200 and 100 nm polycarbonate membranes [26].

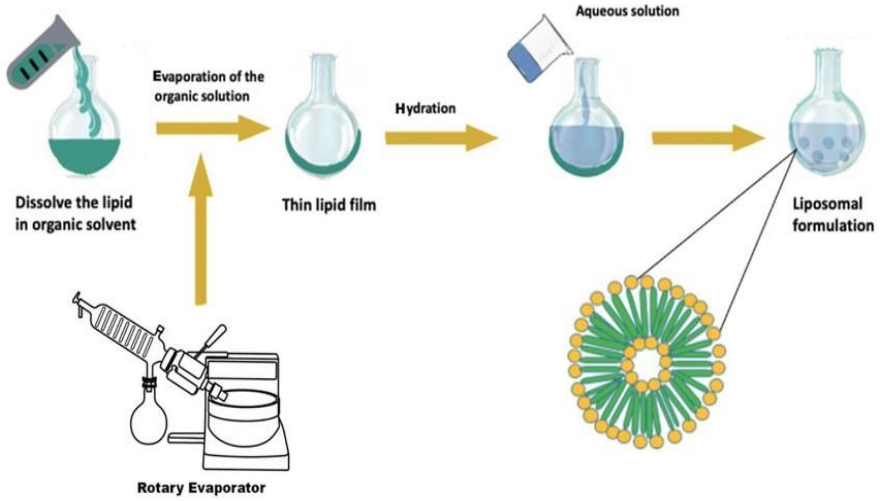

Figure 5: Thin film hydration Method

2. Rotary Film Evaporation Method/ Modified Hand Shaking Method:

Therotary film evaporation method**,** also referred to as thehand-shaking method**,** was firstdeveloped byBangham for the preparation of lipid vesicles. In this technique, the required quantities of phospholipids and surfactants are dissolved in a suitable mixture of organic solvents, typically chloroform and methanol**,** to ensure uniform dispersion. This process is commonly used for the preparation of multilamellar vesicles (MLVs)**.**The resulting solution is transferred into around-bottom flask**,** which is rotated at a controlledtemperature usuallyabove the lipid's glass transition temperatureunder reduced pressure. During this process, a thin lipid film forms on the inner wall of the flask as the solvents evaporate. The dried film, containing both lipids and edge activators, is then hydrated with anaqueous medium**,** allowing the lipid layers to swell and form bilayered vesicles. Finally, sonication orextrusion techniques are applied to achieve the desired vesicle size and uniformity [7]

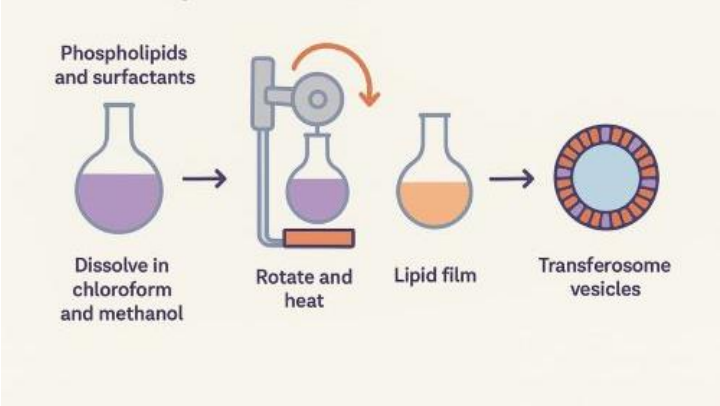

Figure 6: Rotary Film Evaporation Method

3. Reverse-Phase Evaporation Method:

In this method, phospholipids and edge activators are first placed in a round-bottom flask and dissolved in a suitable organic solvent mixture, typically diethyl ether and chloroform. At this stage, a lipophilic drug can be incorporated directly into the organic phase. The solvent mixture is then evaporated using a rotary evaporator, resulting in the formation of a thin lipid film on the inner wall of the flask.Next, the dried lipid film is redissolved in an organic phase, usually containing isopropyl ether and/or diethyl ether. The aqueous phase is gradually added to this organic solution to create a two-phase system. If the formulation involves a hydrophilic drug, it can be added during this step. The resulting mixture is then sonicated in a bath sonicator until a homogeneous water-in-oil (w/o) emulsion is achieved. Finally, the organic solvent is slowly evaporated under reduced pressure using a rotary evaporator, leading to the formation of a viscous gel, which eventually transforms into a stable vesicular suspension [27].

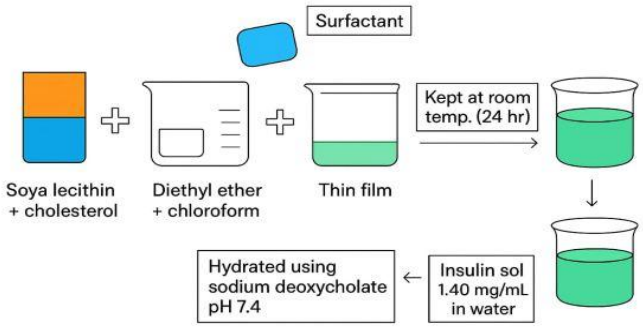

Figure 7: Reverse-Phase Evaporation Method

4. Vortexing /Sonication method:

In this method, a mixture of lipids including edge activators, phosphatidylcholine, and the drug substance is dispersed in a phosphate buffer solution. The mixture is then vortexed thoroughly to form a uniform, milky suspension. Following this, the suspension undergoes sonication to ensure proper vesicle formation and uniform distribution of components. Finally, the resulting dispersion is subjected to extrusion through polycarbonate membranes to obtain vesicles of uniform size and improved stability [7].

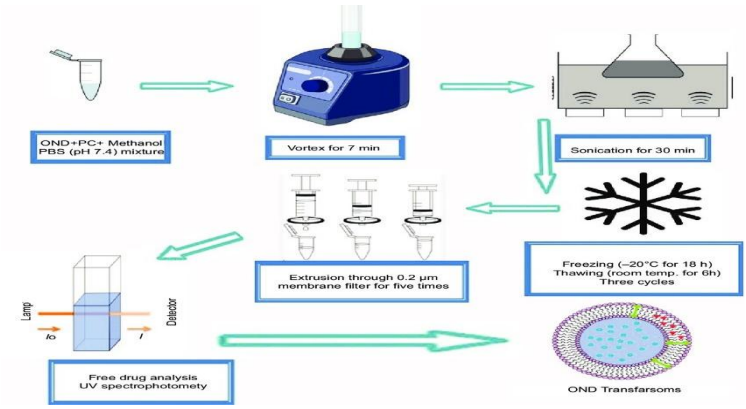

Figure 8: Vortex/Sonication Method

5.

Ethanol injection method:

In this method, the organic phase is prepared by dissolving phospholipids, edge activators (EAs), and active ingredients under magnetic stirring until a clear, uniform solution is obtained. Simultaneously, water-soluble components are dissolved in phosphate buffer to form the aqueous phase. Both solutions are then heated to a temperature range of 45°C to 50°C to ensure complete dissolution and uniform mixing.The phospholipid solution is then slowly injected dropwise into the aqueous phase while continuously stirring, allowing the formation of vesicles. After the mixing process, ethanol present in the system is removed by transferring the dispersion into a vacuum evaporator. Finally, the obtained suspension is subjected to sonication to reduce vesicle size and achieve a stable nanosized formulation [24].

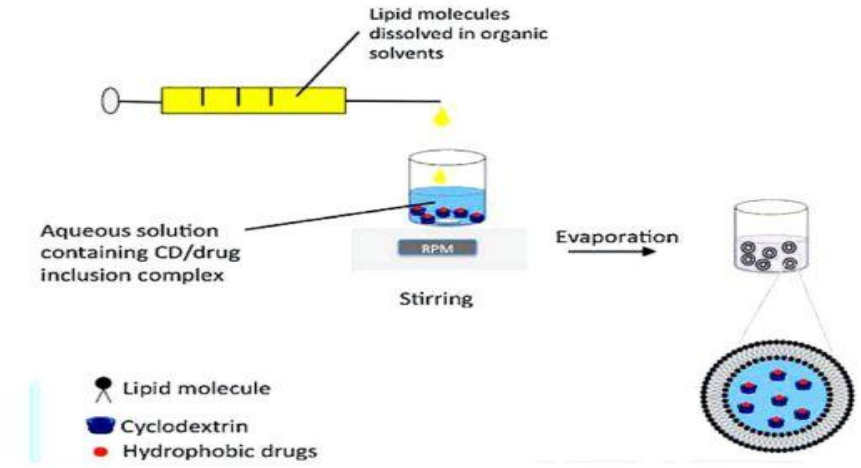

Figure 9: Ethanol Injection Method

Characterization of Transferosomes

Characterization of transferosomes is a crucial step to evaluate their physicochemical properties, stability, and efficiency as drug carriers. Various parameters such as vesicle size, shape, charge, and drug entrapment efficiency play a significant role in determining their performance in transdermal drug delivery.

1. Entrapment Efficacy

The percentage of drug encapsulated within the vesicular formulation is referred to as the percentage entrapment efficiency (%EE). It is determined by separating the unentrapped (free) drug from the vesicles, typically using minicolumn centrifugation. Both direct and indirect methods can be employed to evaluate %EE. In the direct method, the vesicles are first isolated by ultracentrifugation, after which the supernatant is removed and the vesicles are disrupted using 0.1% Triton X-100 or n-propanol to release the encapsulated drug. The resulting solution is then diluted and filtered through a syringe filter (0.22–0.45 µm) to remove impurities. The drug content is finally quantified using either high-performance liquid chromatography (HPLC) or a spectrophotometric method [3].

2. Vesicle size, Morphology and Zeta potential

The vesicle diameter of transferosomes can be determined using the Dynamic Light Scattering (DLS) technique. In this method, the vesicle suspension is mixed with a suitable medium, and size measurements are typically performed in triplicate to ensure accuracy. Alternatively, the sample may be prepared using distilled water and then filtered through a 0.2 µm membrane filter to remove any aggregates or impurities. For DLS analysis, the filtered sample is diluted with saline to obtain an optimal concentration for measurement. The vesicle size and size distribution are then determined using a Malvern Zeta Sizer. Additionally, transmission electron microscopy (TEM) is employed to observe the morphology, surface characteristics, and any structural changes of the vesicles [24].

3. Drug content

The drug content in the formulation can be quantitatively determined using instrumental analytical techniques, most commonly the modified High-Performance Liquid Chromatography (HPLC) method. This method typically employs a UV detector, column oven, autosampler, and pump, along with a computerized data analysis system to ensure precise and accurate quantification of the drug present in the sample [28].

4. Occlusion effect

In topical drug delivery, skin occlusion is generally believed to enhance drug penetration by increasing skin hydration. However, elastic vesicles such as transferosomes also face limitations under occlusive conditions. The primary driving force for vesicle penetration through the skin is the hydrotactic movement of water—from the relatively dry surface of the stratum corneum to the more hydrated deeper layers. When the skin is occluded, this natural water evaporation is prevented, which in turn reduces the hydration gradient. As a result, the driving force for vesicle movement and drug penetration is diminished under occlusive conditions [28].

5. Penetration ability, Surface charge and charge density

Fluorescence microscopy is employed to evaluate the penetration capability of transferosomes through the skin or biological membranes. Additionally, the surface charge and charge density of the transferosomes are determined using a Zetasizer, which measures the zeta potential to assess vesicle stability and electrostatic properties [7].

6. In vitro drug release

The in vitro drug release study is typically conducted using a Franz diffusion cell apparatus. In this setup, the donor chamber is securely attached to the receptor chamber using adhesive tape to ensure proper sealing. The receptor compartment is continuously stirred with a magnetic bar to maintain uniform mixing of the diffusion medium. At predetermined time intervals (such as 0, 0.5, 1, 2, 3, 4, and 6 hours), 1 mL aliquots of the receptor medium are withdrawn for analysis, and an equal volume of fresh phosphate buffer is simultaneously added to maintain sink conditions. The collected samples are then analyzed for drug content using either UV spectrophotometry or High-Performance Liquid Chromatography (HPLC) [24].

7. Stability

Transferosomal formulations are stored in airtight amber vials and subjected to stability testing under various temperature and humidity conditions. According to the guidelines of the International Conference on Harmonization (ICH), long-term storage conditions generally include 25 ± 2 °C / 60% ± 5% RH or 30 ± 2 °C / 65% ± 5% RHfor a duration of 12 months. For accelerated stability studies, formulations are stored at 40 ± 2 °C / 75% ± 5% RH for six months. For pharmaceutical products intended to be stored under refrigeration, the recommended long-term storage condition is 5 ± 3 °C for 12 months, while accelerated testing is carried out at 25 ± 2 °C /60% ± 5% RH for six months. Any deviation from the specified limits during these studies is considered a significant change in the product's stability or quality attributes [28].

8. Penetration Ability and Surface Charge

Fluorescence microscopy and confocal laser scanning microscopy (CLSM) are used to study skin penetration depth and vesicle localization. Zetasizer instruments determine surface charge and charge density, which influence vesicle aggregation and stability [32].

APPLICATION OF TRANSFEROSOMES:-

Transdermal immunization: One of the most important applications of transferosomes is in transdermal immunization, where they are used to deliver soluble proteins such as gap junction protein, human serum albumin, and various integral membrane proteins across the skin. Transferosomes represent a novel and advanced vesicular drug delivery system, functioning as a more flexible and efficient form of liposomes. Because of their elastic and deformable structure, they enable significantly improved penetration through the skin barrier. The components used in transferosome formulations are generally recognized as safe and are already approved for use in cosmetic and pharmaceutical preparations [26].

Delivery of Anticancer Drugs: A research conducted by Jiang et al. in 2018 was associated with the topical chemotherapy of melanoma by transfersome-embedded oligopeptide hydrogels containing paclitaxel prepared by the thin-film dispersion method. Transfersomes composed of phosphatidylcholine, tween80 and sodium deoxycholate were shown to e ectively penetrate into tumor tissues [29].

Insulin Delivery: Transferosomes can improve the bioavailability of insulin by protecting it from degradation in the gastrointestinal tract and increasing its absorption in the intestinal mucosa. Transferosomes can reduce the side effects of insulin, such as hypoglycemia, by controlling the rate of insulin absorption and maintaining a stable blood glucose level. Transferosomes can be used for oral delivery of insulin, which is a non-invasive and patient-friendly method. The first signs of systemic hypoglycemia can appear 90 to 180 minutes after transfersulin injection on the intact skin [19].

Transport of Proteins: Large and complex biogenic molecules, such as peptides and proteins, are often difficult to deliver into the body because they are easily degraded in the gastrointestinal tract when administered orally. Transferosomes offer an efficient alternative for delivering such macromolecules across the skin. Studies have shown that proteins delivered through transferosomes exhibit bioavailability comparable to that obtained through subcutaneous injections. Additionally, when protein preparations such as bovine serum albumin, used as an immunogenic adjuvant were administered repeatedly via epicutaneous transferosomal formulations, they produced a strong immune response. This demonstrates the significant potential of transferosomes for non-invasive, protein-based drug and vaccine delivery [30].

Antifungal Agent Transferosomes: Transferosomes loaded with an antifungal drug were formulated using the Rotary Flask Evaporation followed by sonication technique. To identify the key formulation and processing factors that influence vesicle size, a Plackett Burman experimental design was applied. Variables such as lipid concentration, surfactant quantity, ethanol volume, hydration medium volume, and hydration time were evaluated to determine their impact on the final vesicle characteristics [19].

Delivery of Corticosteroids: In 2003 and 2004, Cevc and Blume conducted studies to evaluate the therapeutic performance of transferosomes loaded with triamcinolone acetonide, a corticosteroid with halogenated activity. The transferosomes were prepared using the conventional thin-film hydration technique. Their findings revealed that the transferosomal formulation provided enhanced and prolonged biological activity compared to conventional forms of the drug. Additionally, the results indicated that an effective therapeutic response could be achieved with a lower dose when administered via transferosomes, demonstrating improved potency and efficiency in drug delivery [30].

SCOPE OF TRANSFEROSOMES

Transferosomes have emerged as an advanced and adaptable vesicular delivery system that bridges the limitations of

conventional topical and transdermal formulations. Their remarkable deformability, biocompatibility, and ability to deliver a wide variety of bioactives open vast opportunities in modern pharmaceutical research and clinical therapy.The primary scope of transferosomes lies in their potential to deliver both small-molecule drugs and macromolecules (such as proteins, peptides, and nucleic acids) through the skin barrier without chemical enhancers Their phospholipid composition mimics biological membranes, ensuring compatibility and safety during prolonged topical use. This makes them suitable forchronic skin disorders**,** localized cancer therapy**,** hormonal replacement**,** andnon-invasive vaccination.Transferosomes also hold tremendous promise in phytopharmaceutical and cosmeticformulations**.** Incorporating herbal bioactives like resveratrol, curcumin, and quercetin into transferosomal vesicles enhances solubility, stability, and bioavailability, thus extending their therapeutic potential in anti-aging, anti-inflammatory, and antioxidant skincare applications.In addition, their integration with novel delivery platforms such ashydrogels, microneedlearrays,and stimuli responsive nanocarriers provides a new direction for controlled and sustained drug release.Continuous advancements in formulation techniques and characterization methods may further support industrial-scale production and clinical translation**.** Overall, transferosomes represent a futuristic approach for site-specific, patient friendly, andeffective transdermal therapy, offering a promising horizon for pharmaceutical innovation and personalized medicine [33].

CONCLUSION

Transferosomes are highly versatile and deformable vesicular carriers that have revolutionized transdermal and dermal drug delivery. Their ultra-flexible bilayer allows them to squeeze through narrow pores of the stratum corneum, enabling deep skin penetration and effective drug targeting. Owing to their amphiphilic nature, they can encapsulate both hydrophilic and lipophilic drugs, offering improved permeability, controlled release, and enhanced bioavailability compared to conventional liposomes and niosomes.

Transferosomes have demonstrated excellent potential in delivering a wide range of therapeutics, including anticancer drugs, corticosteroids, antifungal agents, proteins, peptides, insulin, and herbal bioactives such as resveratrol, curcumin, and quercetin. They provide non-invasive, patient-friendly alternatives to injections and oral formulations, reducing systemic toxicity and improving therapeutic efficacy.However, challenges such as formulation instability, high production cost, and lack of regulatory guidelines remain obstacles to commercialization. Future research should focus on optimizing formulation techniques, improving vesicle stability, and conducting large-scale clinical evaluations. The integration of transferosomes with hydrogels, microneedles, and polymeric systems can further enhance drug delivery efficiency. Overall, transferosomes represent a promising platform for next-generation targeted, controlled, and safe transdermal therapy.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

REFERENCES:

1. Varia U, Joshi D, Jadeja M, Katariya H, Detholia K, Soni V. Development and evaluation of ultradeformable vesicles loaded transdermal film of boswellic acid. Future Journal of PharmaceuticalSciences. 2022;8(1):1–12. doi:10.1186/s43094-022-00428-2.
2. Gupta R, Singhal M, Nimisha. Transferosomes as an efficient carrier system for better therapeutic response of targeted drug delivery system. [Affiliation: Amity Institute of Pharmacy, Amity University, Noida; Faculty of Pharmacy, DIT University, Dehradun].
3. Kumar A, Nayak A, Ghatuary SK, Dasgupta S, Jain AP. Transferosome: a recent approach for transdermal drug delivery. Journal of Drug Delivery and Therapeutics. 2018 Oct 15;8(5-s):100–104
4. Aljarba TM, Alam A, El Kirdasy AF. Novel transferosome formulation of Vemurafenib for skin cancer management: biocompatible and scalable strategies. *Beni-Suef Univ J Basic Appl Sci*. 2025;14:83.
5. Rane B, Mhatre N, Jain A. Next-Generation Nanocarriers for Skin Cancer Therapy via Transdermal Delivery. *Nano Biomedicine and Engineering*. 2025;17(2):232–247.
6. Ali S, Sabir S, Saif N, Farooq N. Transferosomes: A versatile and ultradeformable approach for targeted delivery of anticancer drugs in the treatment of diverse cancers. Biomed Eng Biosci Adv. 2025;6(1):1–6.
7. Rao Kodi S, Reddy MS. Transferosomes: A novel topical approach. J Drug Deliv Ther. *2023*;13(2):126–131.
8. Gayathri H, Sangeetha S. Pharmaceutical development of methotrexate loaded transferosomal gel for skin cancer by DoE approach. Braz J Pharm Sci. 2025;61:e212207.
9. Chen RP, Chavda VP, Patel AB, Chen ZS. Phytochemical delivery through transferosome (phytosome): an advanced transdermal drug delivery for complementary medicines. Front Pharmacol. 2022;13:850862.
10. Sarotsumpan P, Chiu IH, Wu PC, Khong NMH, Liew CV, Chutoprapat R. Development and evaluation of trans-resveratrol-loaded transfersomes: role of cholesterol in formulation design for dermal delivery. Nanotechnol Sci Appl. 2025;18:359–375.
11. Adnan M, Akhter MH, Afzal O, Altamimi ASA, Ahmad I, Alossaimi MA, Jaremko M, Emwas AH, Haider T, Haider MF. Exploring nanocarriers as treatment modalities for skin cancer. *Molecules*. 2023;28(15):5905.
12. Aljarba TM, Alam A, El Kirdasy AF. Novel transferosome formulation of Vemurafenib for skin cancer management: biocompatible and scalable strategies. Beni-Suef Univ J Basic Appl Sci. 2025;14:83.
13. El Zaafarany GM, Awad GAS, Holayel SM, Mortada ND (2010) Role of edge activators and surface charge in developing ultradeformable vesicles with enhanced skin delivery. Int J Pharm 397:164–172
14. Patil SR, Dharashive V, Shafi S, Rudrurkar MN, Kazi AJ, Ritthe PV.Transethosome technology: revolutionizing transdermal drug delivery. Asian Journal of Pharmaceutical Research and Development.2024;12(3):102-109.
15. Ritthe PV, Fugate A, Shafi S, Rudrurkar MN, Kazi AJ, Patil SR, R Sante RU. Unlocking the potential of niosomes: a comprehensive review. Asian Journal of Pharmaceutical Research and Development.2024;12(3):239-246.
16. Opatha SAT, Chutoprapat R, Khankaew P, et al. Asiatic acid-entrapped transfersomes for the treatment of hypertrophic scars: in vitro appraisal, bioactivity evaluation, and clinical study. Int J Pharm. 2024;651:123738. doi:10.1016/j.ijpharm.2023.123738
17. Chavda, V. P., Ertas, Y. N., Walhekar, V., Modh, D., Doshi, A., Shah, N., et al. (2021)

18. Vemula P, Sailaja AK. Transferosomes – A Novel Carrier for Drug Delivery. 2023 Nov.
19. Kadam R, Hosmanii AH. Transferosomes: Pioneering Nanocarriers for Enhanced Drug Delivery. 2025 Mar.
20. Thejani OA, Titapiwatanakun V. Transferosomes: A Promising Nanoencapsulation Technique for Transdermal Drug Delivery. 2020 Sep.
21. Aljarbal TM, Alam A. Novel Transferosome Formulation of Vemurafenib for Skin Cancer Management: Biocompatible and Scalable Strategies. 2025.
22. Jain AK, Kumar F. Transfersomes: Ultradeformable vesicles for transdermal drug delivery. Asian J. Biomater. Res. 2017; 3:1-3.
23. Opatha SA, Titapiwatanakun V, Chutoprapat R. Transfersomes: A promising nanoencapsulation technique for transdermal drug delivery. PharmaceuRajan R, Jose S, Mukund VB, Vasudevan DT. Transferosomes-A vesicular transdermal delivery system for enhanced drug permeation. Journal of advanced pharmaceutical Technology & Research. 2011 Jul; 2(3):138
24. Crasta A, Painginkar T. Transdermal Drug Delivery System: A Comprehensive Review of Innovative Strategies, Applications, and Regulatory Perspectives. 2025 Apr.
25. Sandhiya N, Deepa, Salma R. Transferosomes: Novel Therapeutic Approach Using Drug Delivery. 2024 Jun.
26. Sheo DM, Shweta A, Ram CD, Ghanshyam M, Girish K, Sunil KP, Transfersomes-A novel vesicular carrier for enhanced transdermal delivery of stavudine: Development, characterization and performance evaluation. J Scientific Speculations and Res 2010; 1(1):30-36
27. Sandhiya N, Deepa, Salma R. Transferosomes: Novel Therapeutic Approach Using Drug Delivery. 2024 Jun.
28. Kulkarni PR, Yadav JD, Vaidya KA, Gandhi PP. Transferosomes: An emerging tool for transdermal drug delivery. Int J Pharm Sci Res. 2011; 2(4):735–741.
29. Vemula P, Sailaja AK. Transferosomes – A Novel Carrier for Drug Delivery. 2023 Nov.
30. Magar A, Dharashive V, Shafi S, Kartale G, Bedare S, Bhosale V.Silver nanoparticles: a modern era of nanotechnology. Asian Journal of Pharmaceutical Research and Development. 2024;12(6):118-124.33. Benson, H.A.E. (2006). Phytochemical Delivery via Lipid-BaseRudrurkar MN, Dharashive VM, Shafi S, Kazi AJ.Luliconazole loaded solid lipid nanoparticles for topical delivery. Asian Journal of Pharmaceutical Research and Development. 2024;12(6):43-55.