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Transfersomes: A versatile tool for drug delivery and targeting

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Abstract

Transfersomes are an innovative system designed for targeted drug delivery through the skin. They are a type of liposome made from phosphatidylcholine combined with an edge activator. This unique design allows them to penetrate the skin's outer layer (the stratum corneum) more effectively, either through the intracellular or transcellular pathways. Some of the key advantages of transfersomes include their ability to carry a wide range of drugs, better skin penetration, and their biocompatibility and biodegradability. Transfersomes are adaptable to ambient stress, hence, allowing the ultra-deformable transfersomes to change its membrane composition locally and reversibly, when it is pressed against or attracted into narrow pores. Transfersomes exhibit a flexible structure and higher surface hydrophilicity which play a critical role in the transport of drugs and other solutes using hydration gradients as a driving force to deliver the molecules into and across the skin. Evaluation parameters of transfersomes includes Vesicle size distribution, Zeta potential, Vesicle morphology, Number of vesicles per cubic mm, Entrapment efficiency, Drug content, Turbidity measurement, Degree of deformability, Surface charge, In-vitro drug release, In-vitro skin permeation studies. Transfersomes are incredibly versatile and can be used for controlled drug release, making them ideal for delivering both small and large molecules. They can carry a wide range of drugs, including pain relievers, anesthetics, corticosteroids, sex hormones, anticancer drugs, insulin, gap junction proteins, and albumin. Their ability to transport such diverse compounds makes them a powerful tool in modern medicine for improving drug delivery and effectiveness.

Keywords: Transfersomes; Ultra-Deformable Vesicle; Osmotic Gradient; Fexible; Adaptable

1. Introduction

New advancements in drug delivery systems are sparking interest in the development of more efficient ways to administer medications. One exciting area is vesicular drug delivery systems, which are part of this wave of innovative approaches[1].

The increasing demand for more effective treatments with fewer side effects has sparked exciting innovations in the pharmaceutical world, leading to the development of novel drug delivery systems (NDDS). These systems are designed to tackle the challenges of traditional drug delivery, such as short-lasting effects, difficulty in targeting specific areas, and low solubility or absorption of certain medications.

Drug delivery systems (DDS) are a groundbreaking innovation with many practical applications. They are designed to release medications at a controlled pace and deliver them directly to specific tissues or cell types, ensuring greater precision. Recent advancements, such as nanoparticles, molecularly imprinted polymers, and 3D printing technology, have become hot topics in this area of research. Drug delivery system is a key approach for achieving targeted, accurate, and more effective drug delivery, making treatments safer and more efficient.

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Drug delivery systems (DDS) are designed to improve how medications work in the body by enhancing their effectiveness and safety. These systems can adjust a drug's metabolism, strength, toxicity, and how the body recognizes it, creating a better environment for the drug to work and improving its absorption.

Compared to traditional drug formulations, Drug delivery system offers several important benefits

- Better stability: Drugs are less likely to break down before reaching their target.
- Improved targeting: Medications are delivered more precisely, increasing their concentration where needed and reducing side effects.
- Controlled release: Drug delivery system ensures drugs are released at the right place and time, even allowing breakthroughs like crossing the blood-brain barrier.
- Lower dosages: This minimizes toxicity and improves the overall effectiveness of treatments.

DDS doesn't just deliver drugs to the affected area—it also plays a crucial role in targeting, controlled release, better absorption, and increased stability, making treatments safer and more efficient[2].

Modern drug delivery systems, like colloidal carriers, are revolutionizing the way we treat various conditions. Compared to traditional methods, these systems offer several benefits, such as better penetration of drugs through the skin, reduced hyperpigmentation, and less irritation or burning sensations, even on sensitive or damaged skin.

In recent years, extensive research has focused on developing lipid-based carriers, solid lipid nanoparticles, and other advanced colloidal systems. These carriers include Multiple emulsions, microemulsions, nano emulsions, Liposomes, ethosomes, noisomes, transferosomes, Solid lipid nanoparticles, lipid microparticles, nanostructured lipid carriers, designed to improve how drugs diffuse through the skin, enhance their penetration, and target specific areas more effectively. This not only boosts therapeutic outcomes but also makes treatments safer and more efficient[3].

Transdermal drug delivery systems are medications designed to be applied to the skin in the form of patches or gels. They work by delivering drugs through the skin at a controlled rate, directly into the bloodstream. These systems have evolved significantly in recent years, making it easier to provide consistent, controlled delivery of medications. By targeting specific areas and releasing drugs gradually, transdermal systems can reduce the number and size of doses needed, improving both safety and effectiveness.

Over the past couple of decades, these systems have gained popularity because they avoid the liver's first-pass metabolism, which can break down drugs taken orally, and they help improve bioavailability. They also minimize side effects commonly associated with pills or other oral medications. Today, the transdermal route is one of the most exciting areas of drug delivery research, with nearly 40% of new drug candidates in clinical trials focusing on transdermal or skin-based systems[4].

2. Transfersomes

Transfersome is a trademark owned by the German company IDEA AG, representing its unique drug delivery technology. The name comes from the Latin word *"transferre"* (meaning "to carry across") and the Greek word *"soma"* (meaning "body"), symbolizing a "carrying body". Essentially, a Transfersome is a specially designed vesicle, built to act like a natural cell or one involved in releasing substances (exocytosis). This makes it ideal for delivering drugs in a controlled and potentially targeted way.

What sets Transfersomes apart is their ultra-flexible, self-adjusting membranes. These allow them to bend and squeeze through tiny pores—much smaller than the vesicle itself—making them highly efficient for crossing barriers in the body[5]. A Transfersome is a highly flexible and responsive structure designed to adapt under stress. This unique ability allows it to pass through different barriers in the body with ease. As a result, it works as an effective drug carrier, making targeted drug delivery possible without the need for invasive methods while ensuring a slow and steady release of therapeutic agents[6].

Transfersomes are an exciting breakthrough for improving drug delivery through the skin. What's fascinating is their ability to squeeze through tiny pores in the stratum corneum that are over ten times smaller than they are. This means that even larger vesicles, around 200–300 nm in size, can easily pass through intact skin[7].

Transfersomes are a highly effective option for transdermal drug delivery, as they can deliver larger amounts of active compounds to the deeper layers of the skin. They work by creating an "osmotic gradient," which allows them to pass through the stratum corneum (SC) via either intracellular or transcellular pathways (Chen et al., 2020). What makes them particularly versatile is their ability to carry both water-loving (hydrophilic) and fat-loving (hydrophobic) molecules. This makes them ideal for delivering multiple drugs or a combination of drugs and natural compounds into the bloodstream at the same time. Their ability to penetrate the skin effectively due to their elasticity has been widely researched and is one of the key reasons they are considered so promising for drug delivery[8].

3. Structure

Transfersomes are incredibly flexible lipid bilayer vesicles designed to pass through the skin without breaking apart. A novel vesicular drug carrier system called transfersomes, which is composed of phospholipid, surfactant, and water for enhanced transdermal delivery. Each transferosome has at least one inner water-based compartment surrounded by a specially designed lipid bilayer as described in **Figure 1**. This bilayer's unique flexibility comes from the addition of "edge activators," which make it less rigid and more adaptable[9].Transfersomes are made up of phospholipids and a single-chain surfactant like sodium cholate, deoxycholate, Span 80, or Tween 80. These surfactants, called "edge activators," help loosen the lipid bilayer, making transfersomes much more flexible than liposomes. They can also include up to 10% ethanol and generally have a total lipid concentration of 5–10% in their final aqueous suspension. This unique combination of components gives transfersomes their exceptional flexibility and effectiveness for drug delivery[10].

Transfersomes are applied to the skin without using an occlusive dressing, which allows them to pass through the stratum corneum's lipid layers due to the skin's natural hydration and osmotic forces. They've been used successfully to deliver a wide range of substances, including small molecules, peptides, proteins, and vaccines. According to IDEA AG, transfersomes are capable of penetrating the stratum corneum and deeper skin layers, eventually reaching the bloodstream to deliver their cargo[11].

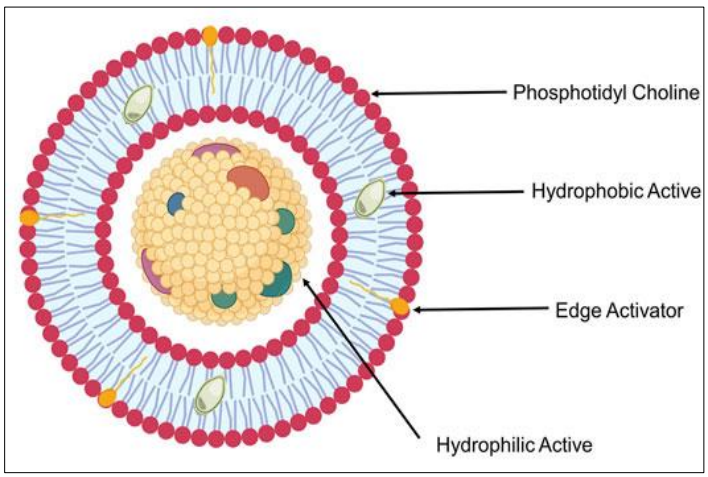

Figure 1 Structure of Transfersome

3.1. Penetration through skin

When something is applied to the skin, it can enter the body through three main pathways:as mentioned in **Table 1**.

Table 1 Pathways for penetration through skin

Hair Follicles and Sebaceous Glands	The substance can travel down the hair follicles and interact with the sebaceous glands, providing an indirect route into the deeper layers of the skin.
Sweat Ducts	It can also pass through sweat ducts, which act as small natural channels into the skin.
Stratum Corneum	The most common route is directly across the stratum corneum, the skin's outermost layer. This layer is a highly organized, lipid-rich barrier that most substances need to overcome to penetrate deeper.

Each pathway plays a role in how substances are absorbed through the skin and can be used strategically for effective drug delivery[11].

The intercellular lipid matrix, which plays a vital role in the skin's protective barrier, is created by keratinocytes in the middle to upper layers of the stratum granulosum. These cells release lamellar structures into the spaces between them. Once in the stratum corneum, this material forms organized lipid bilayers, where the hydrocarbon chains line up tightly, and the polar head groups are surrounded by a thin water layer. This unique structure helps the skin retain moisture and block harmful substances from entering[12].

The way molecules move through the stratum corneum has been extensively studied, with ongoing discussions about whether the intercellular or transcellular pathways play a bigger role and is represented in the **Figure 2**. However, it's now generally accepted that the intercellular lipid route is the main pathway for most small, uncharged molecules to penetrate the skin[13]. For highly hydrophilic molecules, the transcellular route may play a larger role in penetration. However, the lipid bilayers between the keratinocytes remain the main barrier to how quickly these molecules can pass through. Interestingly, using solvents to strip away some of the lipids from the stratum corneum has been shown to increase drug absorption, even for very water-soluble molecules[14].

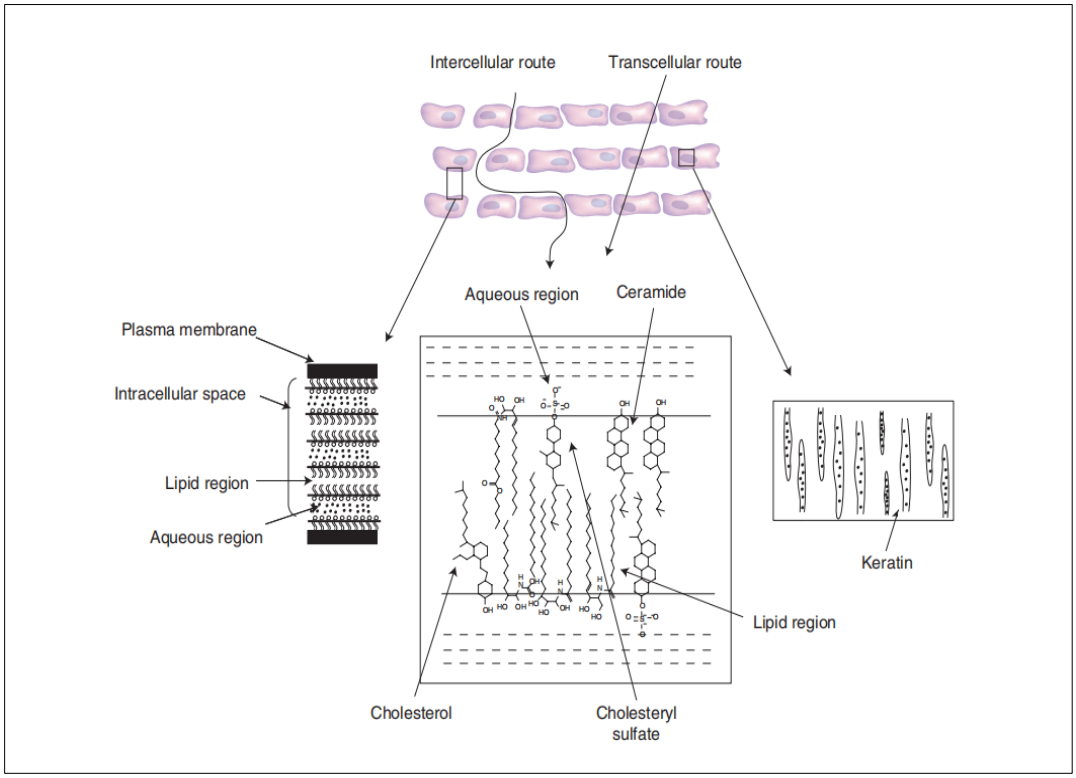

Figure 2 Diagrammatic representation of the stratum corneum and the intercellular and transcellular routes of penetration

4. Advantages

Transfersomes can deform and pass through narrow constriction (from 5 to 10 times less than their own diameter) without measurable loss.

- They have high entrapment efficiency, in case of lipophilic drug near to 90%.
- This high deformability gives better penetration of intact vesicles.
- They can act as a carrier for low as well as high molecular weight drugs e.g. analgesic, anesthetic, corticosteroids, sex hormone, anticancer, insulin, gap junction protein, and albumin.
- Transfersomes possess an infrastructure consisting of hydrophobic and hydrophilic moieties together and as a result can accommodate drug molecules with wide range of solubility.
- They act as depot, releasing their contents slowly and gradually.

- They can be used for both systemic as well as topical delivery of drug.
- They are biocompatible and biodegradable as they are made from natural phospholipids similar to liposomes.
- They protect the encapsulated drug from metabolic degradation.
- Easy to scale up, as procedure is simple, do not involve lengthy procedure and unnecessary use or pharmaceutically unacceptable additives[15].

4.1. Limitations

- Transfersomes are prone to oxidative degradation, which makes them chemically unstable. However, this issue can be greatly minimized by removing oxygen from the solution and replacing it with inert gases like nitrogen or argon[16]. Keeping transfersomes in a cool place and protecting them from light can also help prevent oxidation. Techniques like freeze-drying or spray-drying after preparation can make transfersomes more stable for storage.

- One of the challenges with using transfersomes for drug delivery is the difficulty of getting pure natural phospholipids. A practical solution is to use synthetic phospholipids instead[17].

- Transfersomal formulations tend to be costly because of the expensive raw materials used in lipid excipients and the specialized equipment needed for production. To keep costs down, phosphatidylcholine is often used as it's a more budget-friendly option[15].

4.2. Transfersomes v/s other carrier systems:

At first glance, transfersomes might seem a lot like liposomes, which are lipid bilayer vesicles. But in reality, they're completely different—transfersomes are far more flexible and adaptable than typical liposomes. **Table 2** represents the comparison of different approaches.

Table 2 Comparison of different approaches for permeation enhancement[18].

Method	Advantage	Disadvantage
Liposomes	Phospholipid vesicle, biocompatible, biodegradable	Less skin penetration less stable
Proliposome	Phospholipid vesicle, more stable than liposomes	Less penetration, cause aggregation and fusion of vesicles
Physical methods e.g.iontophoresis	Increase penetration of intermediate size charged molecule	Only for charged drugs, transfer efficiency is low (less than 10%)
Niosomes	Non-ionic surfactants vesicles	Less skin penetration easy handling But will not reach up to deeper skin layer
Proniosomes	Greater stability, Will convert into noisome in situ, stable	Less skin penetration easy handling But will not reach up to deeper skin layer
Transfersomes and Protransfersomes	More stable, high penetration due to high deformability, biocompatible and biodegradable, suitable for both low and high molecular weight and also for lipophilic as well as hydrophilic drugs and reach up to deeper skin layers	None, but for some limitations

Transfersomes are different from mixed micelles in two key ways. First, they're much larger—usually 10 to 100 times bigger than typical lipid micelles. More importantly, transfersomes have a water-filled core, while micelles are just tiny fatty droplets. This unique structure allows transfersomes to carry both water-soluble and fat-soluble substances, unlike micelles, which can only hold fat-soluble ones.

Researchers used Confocal Scanning Laser Microscopy (CSLM) to explore how different carrier systems—like mixed lipid micelles, liposomes, and transfersomes—penetrate intact murine skin. Transfersomes stood out as the most effective, thanks to their flexibility. They were able to move through the stratum corneum and reach the deeper, living layers of the epidermis in significant amounts[6,19,20].

4.3. Mechanism of action

Vesicles are tiny colloidal particles with a water-based core surrounded by a bilayer made of amphiphilic molecules. They're incredibly useful for drug delivery, as they can hold water-soluble drugs inside their core and fat-soluble drugs within their lipid bilayer. Mechanism of action of Transfersomes is as represented in the **Figure 3.**

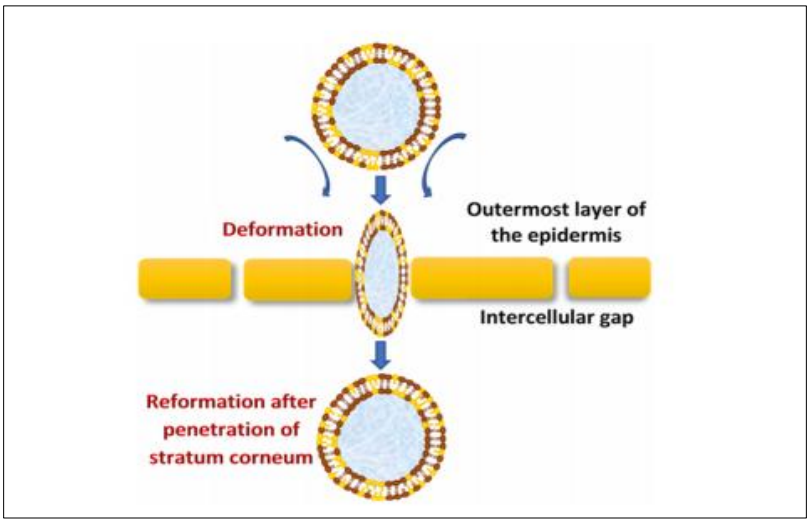

Figure 3 Mechanism of action of Transfersomes

They can penetrate intact skin effectively, but only when applied without covering the skin. This uncovered state is important because it creates an osmotic gradient across the skin, which helps the process[21]. A study by Cevc and Blume found that transfersomes penetrate the skin through a process called hydrotaxis (or xerophobia). This means they're drawn to the deeper, moisture-rich layers of the skin instead of the dry outer surface. This moisture-seeking behavior happens because, after the formulation is applied to the skin without a cover, moisture starts to evaporate, guiding the transfersomes inward[22]. The difference in water activity across the skin, created by the natural transdermal gradient, generates a strong force that acts on transfersomes. This force helps widen the spaces between skin cells, forming tiny channels about 20–30 nm wide. These channels allow the highly flexible transfersomes to pass through the skin, following the hydration gradient[23]. An osmotic gradient forms as water evaporates from the skin's surface due to body heat. This gradient drives the transfersomes to move across the skin, delivering therapeutic agents from the application site to the target area. This process ensures effective treatment with minimal systemic toxicity[2].

4.3.1. Methods of preperation

- Thin film hydration
- Ethanol injection method
- Modified hand shaking method
- Reverse phase evaporation method
- Vortexing sonication method
- High pressure homogenization method

4.4. Thin film hydration / rotary evaporation-sonication method

Transfersomes can be prepared by the thin film hydration method. Required quantities of phosphatidylcholine and surfactant will be taken in a round bottom flask and dissolved in chloroformand ethanol byshaking. The thin film will be formed by rotary evaporation using a rotary evaporator for 15 minutes at 25°C, 600 mm/hg pressure, and 100 rpm. Vacuumwill be applied for one hour to dry the film. The drug will be dissolved in10ml of 7.4 pH phosphate buffer, which will be heated to 55°C. Then the film will be hydrated with the heated buffer by hand shaking for half an hour. The mixture will then be stirred for half an hour in an orbital shaker. Afterward, the transferosomes will be observed under

a microscope. The transfersomal suspension will be stored in a refrigerator at 4°C[24].The diagrammatic representation is shown in **Figure 4**.

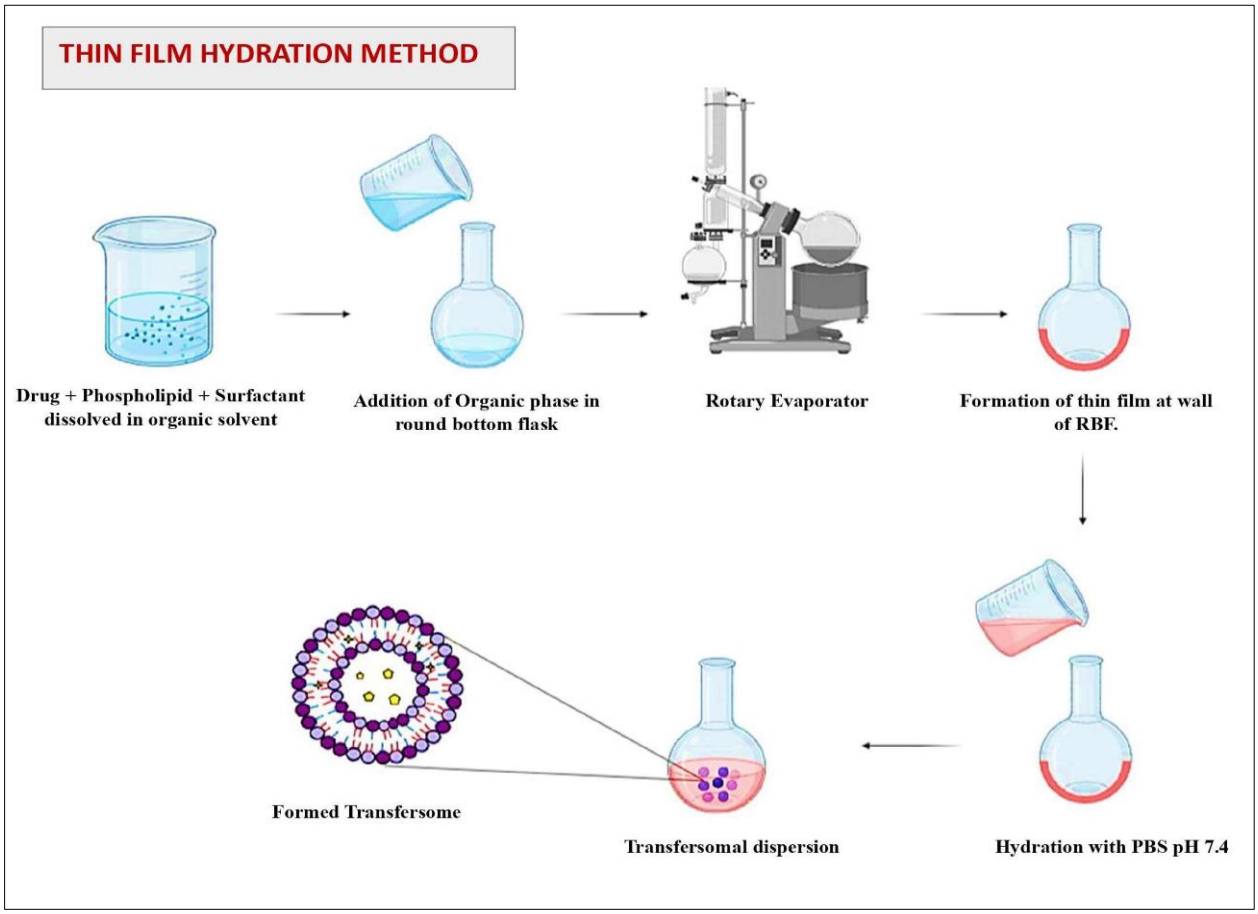

Figure 4 Thin film hydration method

5. Ethanol injection method

Transfersomes will be prepared by the ethanol injection method. Three different steps will be followed:

- Membrane compounds (PC, non-ionic surfactants, and/or cholesterol) will bedissolved in ethanol and injected at 60 °C into a heated phosphate buffer salinity(PBS) at 60 °C and gently stirred at 400 rpm with a magnetic stirrer. 5.6mLof the organic phase will be injected into 50 mL of the aqueous phase (PBS).
- The organic phase will be eliminated using a rotary evaporator in a heatingbath at 50 °C.
- Finally, the prepared transferosomes will be sonicated, and the samples will be ice-cooled to avoid excessive heat from sonication[25].

5.1. Vortexing -sonication method:

The phospholipids, edge activator and the drug are mixed in a phosphate buffer. The mixture is then vortexed until a milky transfersomal suspension is obtained. It is then sonicated, using a bath sonicator, for a respective time at room temperature and then extruded through polycarbonate membranes.(example: 450 and 220 nm)[26].

5.2. Modified hand shaking method

The modified handshaking method has the same basic principle as the rotary evaporation-sonication method. The preparation is shown in flow chart in **Figure 5**.In the modified handshaking process, the organic solvent, the lipophilic drug, the phospholipids and edge activator are added in a round-bottom flask. All the excipients should completely dissolve in the solvent and obtain a clear transparent solution. Then, the organic solvent is removed by evaporation while handshaking instead of using the rotary vacuum evaporator.In the meantime, the round-bottom flask is partially

immersed in the water bath maintained at a high temperature (example: 40–60 ◦C). A thin lipid film is then formed inside the flask wall. The flask is kept overnight for complete evaporation of the solvent. The formed film is then hydrated with the appropriate buffer solution with gentle shaking at a temperature above its phase transition temperature. The hydrophilic drug incorporation can be done in this stage.The resultant vesicles formed are bath sonicated, then sonicated vesicles extruded through a bed of polycarbonate membrane(100-200nm) and finally transfersomal suspension is formed[10].

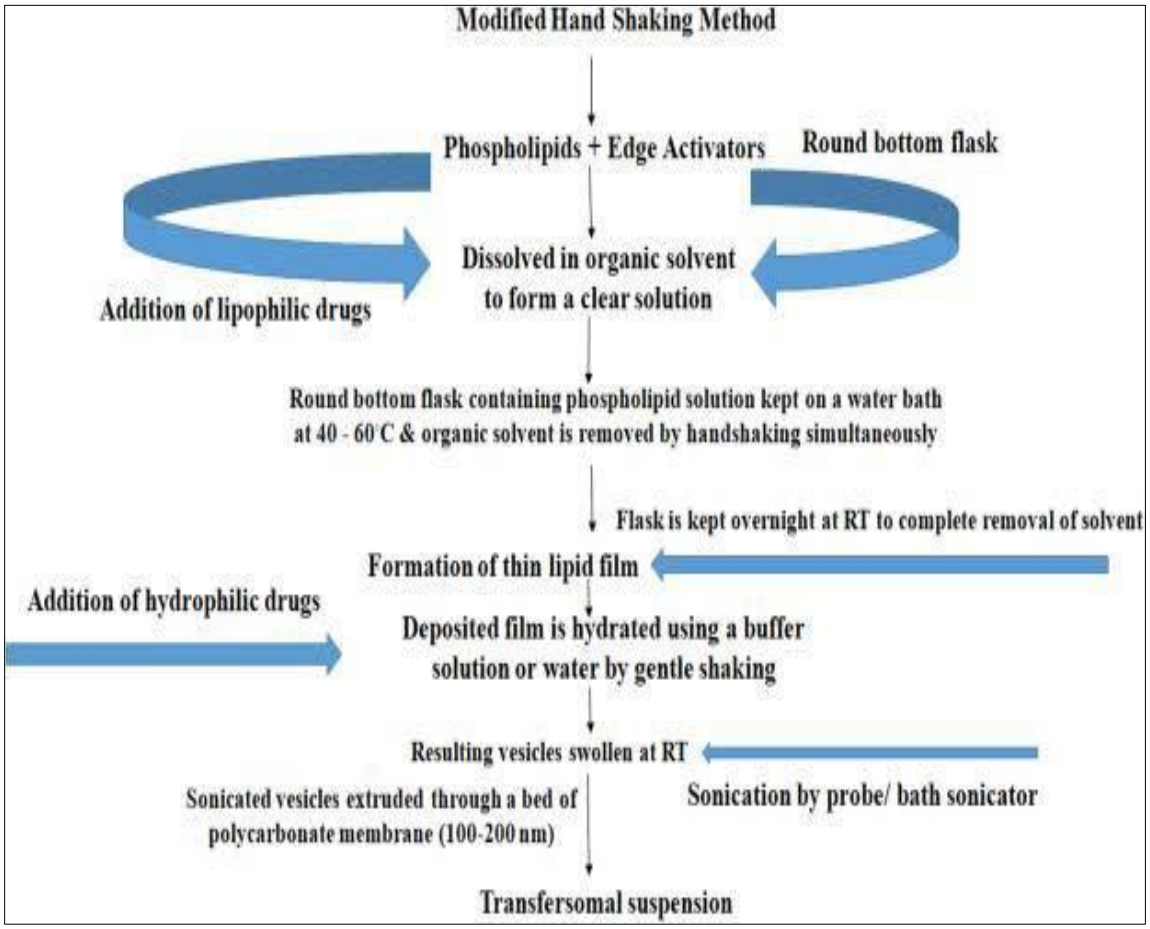

Figure 5 Modified hand shaking mathod

5.3. Reverse phase evaporation method

The phospholipids and edge activator are added to a round-bottom flask and dissolved in the organic solvent mixture (example: diethyl ether and chloroform). The lipophilic drug can be incorporated in this step. Then, the solvent is evaporated using rotary evaporator to obtain the lipid films. The lipid films are redissolved in the organic phase mostly composed of isopropyl ether and/or diethyl ether. Subsequently, the aqueous phase is added to the organic phase, leading to a two-phase system. The hydrophilic drug incorporation can be done in this stage. This system is then subjected to sonication using a bath sonicator until a homogeneous w/o (water in oil) emulsion is formed. The organic solvent is slowly evaporated using rotary evaporator to form a viscous gel, which then becomes a vesicular suspension[27] as shown in **Figure 6**.

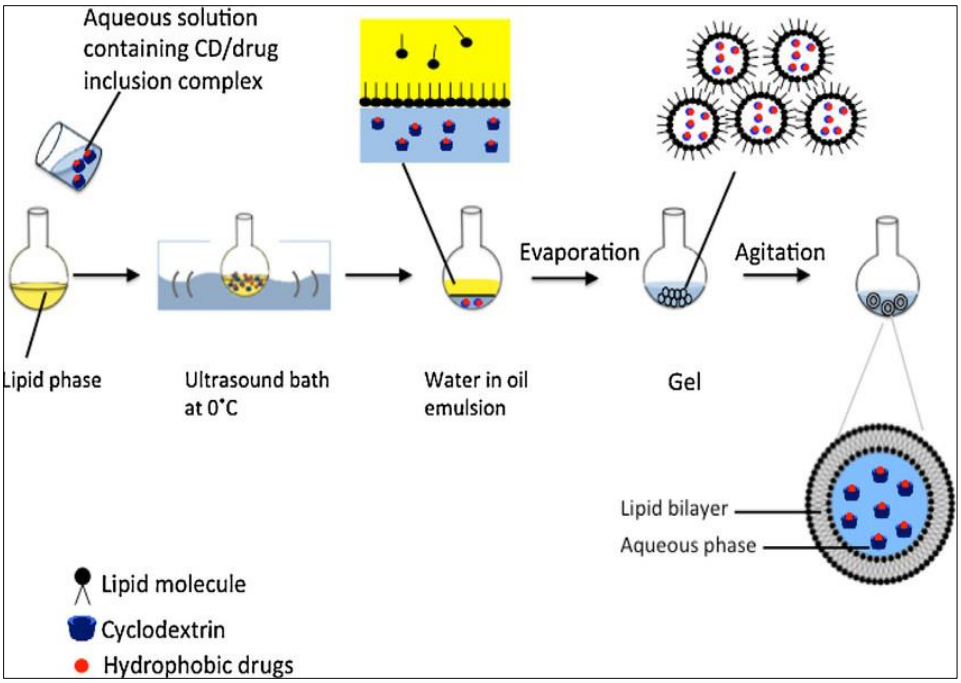

Figure 6 Reverse phase evaporation method

5.4. High pressure homogenization method

The phospholipids, edge activator and the drug are uniformly dispersed in PBS or distilled water containing alcohol and followed by ultrasonic shaking and stirred simultaneously. The mixture is then subjected to intermittent ultrasonic shaking. The resulting mixture is then homogenized using a high-pressure homogenizer. Finally, the transfersomes are stored in appropriate conditions28.

6. Evaluation of transfersomes

6.1. Vesicle size distribution and zeta potential

Vesicle size, size distribution and zeta potential were determined by Dynamic Light Scattering system by Malvern Zeta sizer.

6.2. Vesicle morphology[29]

The diameter of vesicles can be measured using photon correlation spectroscopy or dynamic light scattering (DLS). To prepare the samples, they were suspended in distilled water, filtered through a 0.2 mm membrane, diluted with filtered saline, and then analyzed for size using DLS. Transfersome vesicles can also be visualized using techniques like electron microscopy (EM) or phase-contrast microscopy. To assess the stability of the vesicles, their size and structure were monitored over time. Mean size was measured with DLS, while any structural changes were observed using transmission electron microscopy (TEM).

6.3. No. of vesicles per cubic mm[30]

This is an essential step in optimizing the composition and refining process variables. Non-sonicated transfersome formulations are diluted 1:5 with 0.9% sodium chloride solution. A haemocytometer and an optical microscope are then used for analysis (19). The number of Transfersomes in 80 small squares is counted and calculated using the following formula:

- Total number of transfersomes per cubic mm =
- (Total number of transfersomes counted × dilution factor × 4000) /Total number of squares counted.

6.4. Entrapment Efficiency (%EE)[31,32,33]

Entrapment efficiency (%EE) refers to the percentage of drug successfully encapsulated in the formulation. To determine %EE, unentrapped drug is separated from the vesicles using methods like mini-column centrifugation. Both direct and indirect approaches can be used for this measurement.

In the direct method, after ultracentrifugation, the supernatant is removed, and the sedimented vesicles are disrupted using a suitable solvent that lyses the vesicles. The resulting solution is then diluted and filtered through a syringe filter (0.22–0.45 µm) to remove any impurities. The drug content is then measured using analytical techniques such as high-performance liquid chromatography (HPLC) or spectrophotometry, depending on the specific requirements of the active pharmaceutical ingredient (API) [83,90,91]. The entrapment efficiency (%EE) is calculated using the following formula:

$$\%\text{Entrapment efficiency} = \text{Amount of the drug entrapped} / \text{Total amount of the drug added} \times 100$$

In the indirect method, the supernatant is diluted with a suitable solvent and filtered to remove any impurities. The concentration of the free drug in the supernatant is then measured using an appropriate analytical technique. From this, the percentage of drug entrapment (%EE) can be calculated using the following formula:

$$\%\text{Entrapment efficiency} = \text{Total amount of the drug added} - \text{Amount of the free drug} / \text{Total amount of the drug added} \times 100$$

6.5. Degree of Deformability[21,34,35]

This parameter is important because it impacts how well the transfersomal formulation can permeate. The study uses pure water as the standard. The formulation is passed through a series of microporous filters with pore sizes between 50 and 400 nm. After each pass, the particle size and size distribution are measured using DLS (Dynamic Light Scattering). The degree of deformability is then calculated as:

$$D = j\left(\frac{rv}{rp}\right)$$

Where
D = degree of deformability,
J = amount of suspension extruded during 5 min,
rv = size of the vesicle and
rp = pore size of the barrier.

6.6. Drug content[30]

The drug content can be measured using instrumental techniques like modified high-performance liquid chromatography (HPLC), which involves a UV detector, column oven, autosampler, pump, and computerized analysis software. The choice of method depends on the specific requirements of the pharmacopoeial drug.

6.6.1. Turbidity measurement[19]

Turbidity of drug in aqueous solution can be measured using nephelometer.

6.6.2. Surface charge and charge density:

Surface charge and charge density of Transfersomes can be determined using zetasizer.

6.6.3. Penetration ability[36]

Penetration ability of Transfersomes can be evaluated using fluorescence microscopy.

6.6.4. In-vitro drug release[37]

The in vitro release of the Transfersomes was measured using vertical glass Franz diffusion cells. Nylon66 filters (0.20 µm pore diameter, Millipore Isopore™, USA) were soaked in isopropyl myristate to simulate the lipophilic nature of the stratum corneum (SC). A 0.3 g sample was applied to the donor compartment, while the receptor compartment was

filled with a 25% alcohol solution. The receptor compartment was kept at 32 ± 0.5°C and stirred continuously at 200 rpm. Samples from the receptor solution were taken at set time intervals.

6.6.5. In-vivo permeation[38]

A 2 × 3 cm area of dorsal skin from SD rats was shaved, and an equal amount of vesicular gel and tacrolimus ointment was applied evenly. After 24 hours, the permeation experiment was concluded, and the rats were anesthetized with chloroform. Blood (1 ml) and skin samples from the application site were collected from each rat. Following the method outlined by Babu et al., the skin layers were separated. The stratum corneum (SC) was removed by tape stripping, collecting 10 strips. The remaining skin was frozen at -50°C and sectioned into epidermis and dermis using a cryo-microtome (CM1900 Leica, Germany). The epidermis was sliced into four 25 µm thick sections, and the remaining tissue was collected as dermis. These skin layers were chopped and extracted in methanol using homogenization (IKA® Wiggens D-120, Germany). The samples were kept refrigerated for 12 hours, then centrifuged to obtain the supernatant for tacrolimus content analysis. Blood samples were processed as described by Lee et al.

7. Application of transfersomes

7.1. Delivery of Antioxidants

In 2017, Avadhani et al. developed nano transfersomes containing epigallocatechin-3-gallate (EGCG) and hyaluronic acid using a modified thin-film hydration method, followed by high-pressure homogenization. These transfersomes were created to improve the effectiveness of EGCG and hyaluronic acid as UV protectors, antioxidants, and anti-aging agents[39].

In 2019, Wu et al. prepared transfersomes with resveratrol using the same high-pressure homogenization technique. Their results showed that the transfersomes enhanced the stability, bioavailability, solubility, and safety of resveratrol[27].

7.2. Delivery of Corticosteroids[40]

The biological activity and characteristics of halogenated corticosteroid triamcinolone-acetonide-loaded transfersomes prepared by the conventional thin-film hydration technique were studied by Cevc and Blume in 2003 and 2004. The results showed that transfersomes had increased the biological potency and prolonged effect, as well as the reduced therapeutic dosage.

7.3. Delivery of Anti-Inflammatory Drugs[26,41]

Diclofenac sodium, celecoxib, mefenamic acid and curcumin-loaded transfersomes were developed and studied for the purpose of topical administration by several research groups. Research findings suggested that transferomes could improve the stability and efficacy of the anti-inflammatory drugs.

7.4. Delivery of Anticancer Drugs[42]

Aresearch 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 effectively penetrate into tumor tissues.

7.5. Delivery of insulin[43]

By transferosomes is the successful means of noninvasive therapeutic use of such large molecular weight drugs on the skin. Insulin is generally administered by subcutaneous route that is inconvenient. Encapsulation of insulin into transferosomes (transfersulin) overcomes these entire problems. After transfersulin application on the intact skin, the first sign of systemic hypoglycemia are observed after 90 to 180 min, depending on the specific carrier composition.

8. Conclusion

Transfersomes are specially designed, ultra-flexible vesicles that can change shape quickly and effortlessly in response to external stress. This unique ability allows them to transport drugs across biological barriers like the skin. In lab tests, transfersomes have been shown to pass through tiny pores as small as 100 nm—almost as easily as water, even though water molecules are about 1,500 times smaller. This makes them a powerful tool for improving drug delivery, especially

for medications that have trouble penetrating the skin on their own. Transfersomes have a special structure that contains both water-loving (hydrophilic) and fat-loving (hydrophobic) components, allowing them to carry a wide variety of drugs, regardless of their solubility. This makes them a highly versatile option for transdermal drug delivery. Transfersomes are specially designed drug carriers that need to be customized for each medication to ensure they work as effectively as possible. Their ability to adapt makes them a powerful tool in drug delivery, but fine-tuning their formulation is essential for the best results. As research on transfersomes continues, they could open the door to new and promising treatments for a variety of diseases.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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