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Review Article

Emerging Trends in Liposomal and Phospholipid Excipients for Cosmetic Applications

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ABSTRACT

These are novel excipients which have become increasingly popular in recent cosmetics and cosmeceuticals because of their high compatibility, amphiphilic behavior, and capability of improving active ingredient delivery [7,16]. The use of such systems increases stability, penetrability, and controlled release of bioactives, thus improving product efficacy [12,13]. Since liposomes are vesicles, they can entrap both hydrophilic and lipophilic compounds, giving them greater applicability in cosmetic products [9]. This review talks about the chemical structure, properties, how to make them, how they work, their benefits, how they are used, and what the future holds for liposomes and phospholipids in cosmetics [8,16]. Some of the newest trends in the cosmetics industry are nanotechnology, biotechnology, personal care, and green formulations [6,17]..

INTRODUCTION

Cosmetics and cosmeceuticals have improved a lot thanks to new developments in dermatology, nanotechnology, and pharmaceutical sciences [5,17]. Cosmetics are meant to make you look better, but cosmeceuticals have biologically active ingredients that are good for your skin [16]. People today want products that are not only pretty but also safe and based on science. Penetration of biologically active substances deep inside the skin layer is one of the key problems in designing effective cosmetics [20]. The outer skin layer acts as a strong barrier hindering the penetration of majority of compounds [22]. Moreover, instability, oxidation, degradation, and the irritating effects of biologically active substances restrict their efficacy. To get around those problems, people use highly effective excipients like phospholipids and liposomes a lot [7]. Excipients act as an active delivery system that makes sure that substances are highly bioavailable, protects sensitive compounds, and allows for controlled and targeted release of substances

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[9,12]. Pollution, UV rays, and other environmental factors as well as changes in lifestyles have driven a demand for advanced systems delivering active ingredients [17].

Phospholipids as Cosmetic Excipients

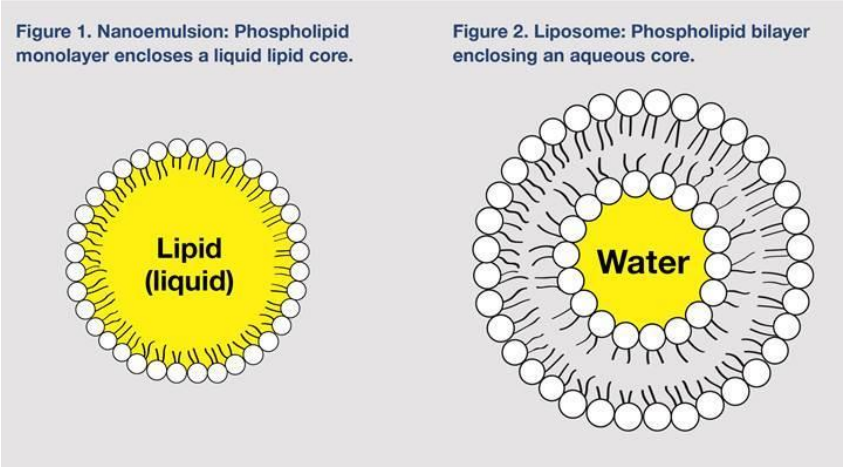
Phospholipids are natural amphiphilic molecules made up of a polar head group and two hydrophobic fatty acid chains that are attached to a glycerol molecule [8]. They are great for cosmetics because they can interact with both the water and lipid phases because of their unique structure.

Chemical Structure and Properties

Phospholipids consist of:

- Glycerol backbone
- Two fatty acid chains (hydrophobic region)
- Phosphate group with polar head (hydrophilic region)

Their amphiphilic nature allows them to form bilayers and vesicular structures, which are essential for drug delivery systems [9,10].



(Fig. 1: Nanoemulsion: Phospholipid monolayer encloses a liquid lipid core.)
(Fig. 2: Liposome: Phospholipid bilayer enclosing an aqueous core.)

Sources of Phospholipids

- Soy lecithin
- Egg yolk lecithin
- Marine sources
- Synthetic phospholipids

Types of Phospholipids

- Phosphatidylcholine (PC)
- Phosphatidylethanolamine (PE)
- Phosphatidylserine (PS)
- Hydrogenated phospholipids

Functions of Phospholipids

- Act as natural emulsifiers in creams and lotions
- Enhance skin hydration and moisturization
- Improve permeability of active ingredients
- Restore and strengthen the skin barrier
- Assist in formation of liposomes and vesicles

Advantages

- Biodegradable and non-toxic
- Excellent compatibility with skin
- Improve formulation stability
- Reduce irritation
- Provide controlled release

Role in Skin Care

As phospholipids simulate natural skin lipids, they contribute to damaged skin repair, hydration regulation, increase skin elasticity, and enhance overall skin condition [20].

Liposomes in Cosmetics

Liposomes are tiny vesicles that have one or more layers of phospholipids around a compartment that is full of water [8]. Liposomes are often used as carriers in cosmeceutical products because they can hold both hydrophilic and lipophilic substances [9].

Structure of Liposomes

- Phospholipid bilayer
- Aqueous inner core
- Amphiphilic arrangement

Types of Liposomes

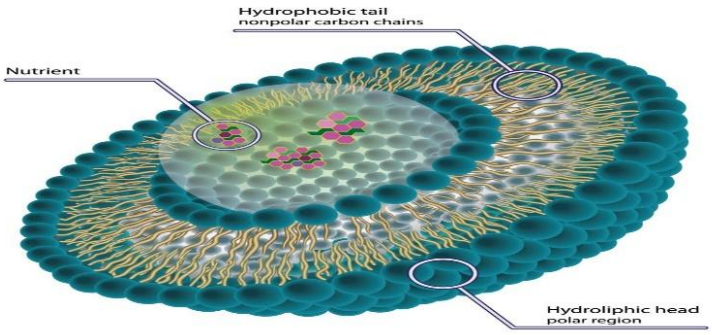
- Small Unilamellar Vesicles (SUVs)
- Large Unilamellar Vesicles (LUVs)
- Multilamellar Vesicles (MLVs)
- Nanoliposomes
- Stealth liposomes (PEGylated)

Preparation Methods

- Thin film hydration method
- Sonication method
- Reverse-phase evaporation
- Microfluidization

Mechanism of Action

Liposomes adhere to the skin surface and interact with the lipid layers of the stratum corneum. They fuse with skin lipids and release encapsulated active ingredients in a controlled manner [12,20]. This enhances penetration into deeper layers and improves effectiveness [13].



(Fig. 3: Mechanism of liposome penetration through skin layers.)

Factors Affecting Performance

- Particle size
- Surface charge
- Lipid composition
- pH and temperature
- Storage conditions

Role of Phospholipids and Liposomes in Cosmeceuticals

Phospholipids and liposomes significantly improve the performance of cosmetic formulations by enhancing delivery and stability of active ingredients [16,17].

- Enhance delivery of vitamins (A, C, E)
- Improve anti-aging effects
- Stabilize antioxidants and peptides
- Increase hydration and elasticity
- Reduce irritation and toxicity
- Provide targeted delivery

They also protect ingredients from oxidation, hydrolysis, and environmental degradation [7].

Comparison with Other Nanocarriers

Liposomes are more biocompatible and flexible as well as capable of transporting lipophilic and hydrophilic agents compared to solid lipid nanoparticles and nanoemulsions [18,19]; however, they might be less stable than the latter [19].

Applications in Cosmetic Formulations

Application	Role of Liposomes/Phospholipids
Anti-aging creams	Deliver retinoids and peptides
Sunscreens	Improve UV filter stability
Moisturizers	Enhance hydration
Acne treatment	Controlled release
Skin brightening	Stabilize vitamin C
Hair care	Repair and conditioning

Commercial Applications

Liposome-based products are often used in anti-aging serums, sunscreens, moisturisers, and dermatological formulations because they work better and are more popular with customers [16].

Current Trends in Cosmetics and Cosmeceuticals

1. Cosmetics that use nanotechnology

Nanotechnology improves the penetration, stability, and controlled release of active ingredients. Liposomes, nanoemulsions, and solid lipid nanoparticles are all used in a lot of different ways.

2. Clean and Sustainable Beauty

More and more people are using biodegradable materials, natural phospholipids, and packaging that is good for the environment.

3. Personalized Skincare

More and more people are using AI to analyse their skin and make personalised products.

4. Advanced Delivery Systems

Stimuli-responsive and targeted delivery systems are being developed for improved efficacy.

5. Hybrid Cosmeceuticals

Products combining cosmetic and therapeutic benefits are gaining demand.

6. Microbiome-Friendly Products

Preservation of skin flora via advanced delivery techniques is another emerging trend.

7. Role of Biotechnology

Biotechnology is helping create safer and more efficient ingredients and delivery techniques.

Advantages Over Conventional Excipients

- Improved skin penetration

- Enhanced stability
- Controlled and sustained release
- Reduced side effects
- Increased bioavailability
- Better product performance

Limitations

- High production cost
- Stability issues
- Leakage of encapsulated ingredients
- Complex manufacturing
- Storage sensitivity
- Regulatory challenges

Evaluation Parameters of Liposomes

- Particle size analysis
- Zeta potential
- Encapsulation efficiency
- Stability testing
- In-vitro release studies

Challenges in Industrial Production

- Difficulty in maintaining uniform size
- High cost of production
- Scale-up challenges
- Stability during storage and transport

Future Perspectives

The future of phospholipids and liposomes includes the development of smart and stimuli-responsive delivery systems, integration with artificial intelligence, and increased use in personalized skincare [6,17]. The cosmetics industry will be built on being environmentally friendly and sustainable. Nanotechnology and biotechnology are always coming up with new ideas, which will help their uses grow a lot.

CONCLUSION

Phospholipids and liposomes have changed the cosmetics and cosmeceuticals industry in a big way because they are not just inert carriers but also effective delivery systems. With ongoing research and technological advancements, these excipients will continue to play a crucial role in the future of cosmetic science.

Illustrations

Fig. 4: Herbal cosmetic ingredients.

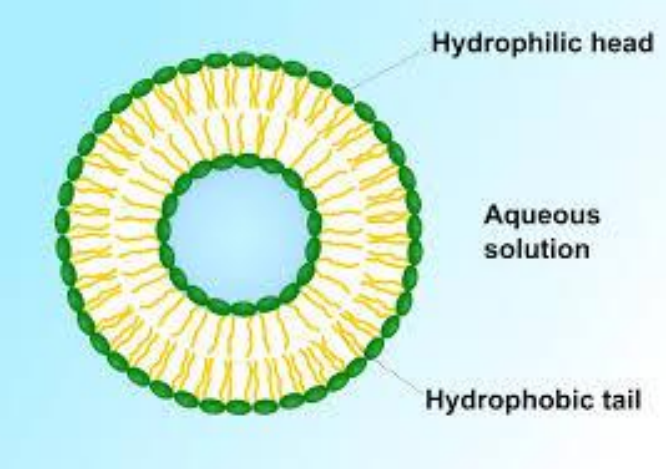


Fig. 5: Liposome nanotechnology.

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