

EMULGEL DRUG DELIVERY SYSTEMS FOR ANTI-PIGMENTATION THERAPY: FORMULATION, EVALUATION, AND APPLICATIONS

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DOI: <https://doi.org/10.5281/zenodo.22159549>

How to cite this Article: Ketan Rathod*, Ritu Chandel, Nandini More, Vinita Gunti, Chhaya Koshti, Ansh Tilala. (2026). Emulgel Drug Delivery Systems For Anti-Pigmentation Therapy: Formulation, Evaluation, and Applications. World Journal of Pharmaceutical and Life Sciences, 12(9), 1–5.

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Article Received on 22/07/2026

Article Revised on 12/08/2026

Article Published on 01/09/2026

ABSTRACT

Pigmentation disorders, arising from irregular melanin production or distribution in the skin, significantly impact cosmetic appearance and quality of life. Topical formulations are frequently used for managing hyperpigmentation, with recent advancements focusing on emulgel systems that combine the benefits of gels and emulsions. **Emulgels** offer improved drug release, better penetration, and enhanced stability compared with conventional creams or gels, especially for hydrophobic actives. This review discusses **pigmentation, skin structure and permeability**, emulgel formulation and rationale, comparison with conventional dosage forms, advantages, key ingredients, method of preparation, evaluation and stability parameters, storage, usage, precautions, and future prospects.

KEYWORDS: Anti-pigmentation, Emulgel, Topical Delivery, Skin Permeability, Hydrophobic Drugs.

INTRODUCTION TO PIGMENTATION

Pigmentation refers to the color of the skin influenced by melanin, a pigment produced by melanocytes. Disorders such as melasma, post-inflammatory hyperpigmentation, and age spots occur due to increased melanogenesis or uneven melanin distribution. These conditions can be triggered by **ultraviolet (UV) exposure, hormonal changes, inflammation, or aging processes**.

Numerous internal and environmental variables, such as hormone fluctuations, inflammation, trauma, acne, eczema, certain medications, UV exposure, etc., can cause these color changes in the skin.

Current therapeutic strategies often present limitations such as side effects, poor efficacy, or stability issues.

Therefore, novel drug delivery formulations are prepared for curing hyperpigmentation such as: emulgels, pigmentation patches, overnight masks or creams, etc.

Types of Pigmentation

(General dermatology knowledge; standard clinical categorization)

Skin Structure and Its Permeability

The skin consists of three major layers:

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The skin consists of three major layers:

- **Epidermis:** Outer layer including the stratum corneum, which is the primary barrier to drug penetration.
- **Dermis:** Middle layer of connective tissue with blood vessels.
- **Hypodermis:** Inner fatty layer that provides insulation and support.

Drug passage occurs mainly via

- **Intercellular route:** Between corneocytes.
- **Transcellular route:** Through corneocytes.

The **stratum corneum** is the major obstacle due to tightly packed lipid layers that restrict hydrophilic and large molecules. Enhancers or suitable vehicles are needed to facilitate penetration.

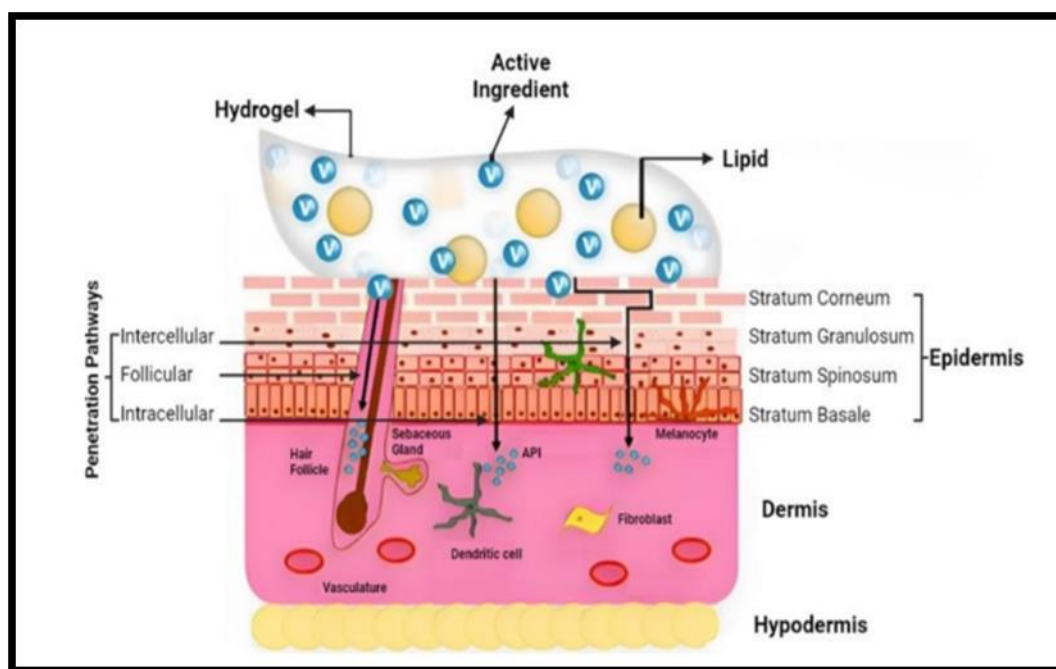


Fig. No. 01: Skin structure and emulgel.

Emulgel: Introduction

An emulgel is a **dual-phase topical system** combining an **emulsion (oil in water or water in oil)** and a **gel matrix**. The emulsion carries hydrophobic actives, while the gel base provides thixotropic properties, ease of spreadability, and prolonged contact time on the skin surface.

Emulgels have gained interest for both therapeutic and cosmetic applications due to their unique performance advantages.

Emulgel comprises of a biphasic system incorporated into a gel base with **oil-in- water or water-in-oil** types. This combination enhances the formulation's stability, the drug's permeation through the skin, bioavailability, and delivery of hydrophilic and lipophilic Drugs.

Types of Emulgel

1. **Oil-in-Water (O/W)** – Oil droplets dispersed in a continuous water phase.
2. **Water-in-Oil (W/O)** – Water droplets dispersed in a continuous oil phase.
3. **Lipo-gel** – Emulgel enhanced with lipophilic components for better penetration.
4. **Nano-Emulgel** – Utilizes nano-sized droplets for superior delivery.

Rationale for Emulgel in Anti-pigmentation

Conventional creams or ointments often:

- Are greasy, sticky, or less cosmetically elegant.
- Show lower penetration for hydrophobic compounds.
- Have limited control over release profiles.

Emulgels address these limitations by **combining both emulsion and gel features**, enhancing hydrophobic drug

incorporation, permeability, and patient acceptability.

Comparison: Emulgel vs Conventional Dosage Forms
Emulgels demonstrate superior spreadability, lower oiliness, and better control over drug release compared with standard semisolids.

Advantages of Emulgel

- Improved delivery of hydrophobic active agents.
- Thixotropic and non-greasy, pleasant feel.
- Enhanced stability and controlled release.
- Good patient compliance due to easy spreadability.
- Long shelf life and transparency.
- Herbal emulsions can improve skin texture, hydration, and overall skin health by reducing oxidative stress and promoting collagen synthesis.
- They provide a natural alternative to synthetic products, appealing to consumers looking for safer skincare options.
- These emulsions can be used in various forms, such as face packs or serums, making them suitable for different skin types and concerns.
- These benefits make herbal Antipigmentation emulsions a popular choice in modern skincare formulations.

Applications of emulgel

- Dermatological therapy – Treats acne, eczema, psoriasis, and dermatitis.
- Antipigmentation and cosmetic use – Delivers depigmenting agents for melasma, freckles, and age spots.
- Hydrophobic drug delivery – Improves solubility and skin penetration of poorly water-soluble drugs.
- Anti-inflammatory and analgesic therapy – Topical relief for localized pain and inflammation.

- Delivery of Hydrophobic Drugs - Improves solubility and penetration of poorly water-soluble drugs through the skin.
- Controlled and Sustained Drug Release - Provides prolonged drug action and reduced frequency of application.

List and Role of Ingredients

1. **Liquorice Extract** – Skin-lightening via tyrosinase inhibition and antioxidant effects.
2. **Manjistha Extract** – Traditional extract with antioxidant and anti-inflammatory actions (cosmetic use).
3. **Green Tea Extract** – Polyphenols like EGCG reduce oxidative stress and may inhibit melanogenesis.
4. **Coconut Oil** – Moisturizing base and skin-conditioning agent. (*Common cosmetic ingredient*)
5. **Xanthan Gum** – Natural gelling agent, increases viscosity.
6. **Cetyl Alcohol** – Emollient, thickening agent.
7. **Polyethylene Glycol (PEG)** – Solvent and penetration enhancer.
8. **Tween 20** – Surfactant/emulsifier stabilizing the O/W system.
9. **Tween 40** – Emulsifier facilitating stable emulsion.
10. **Disodium EDTA** – Chelating agent, enhances stability. (*Standard formulation principle*)
11. **Orange Oil** – Penetration enhancer and fragrance. (*Cosmetic excipient function*)
12. **Triethanolamine** – pH adjuster in gels.
13. **Beeswax** – Thickener and emollient. (*Common excipient knowledge*)



Fig. No. 2: Liquorice Extract.



Fig No: 3 Green-Tea Extract.



FIG NO: 4 Manjistha Extract.

Method of Preparation

Prepare Oil Phase

- Coconut Oil + Beeswax + Cetyl Alcohol + Orange Oil + Lipophilic extracts (Liquorice, Manjistha, Green Tea)
- Heat gently



Prepare Aqueous Phase

- Water + Tween 20 + Tween 40 + Polyethylene Glycol + Disodium EDTA
- Heat to same temperature



Form Emulsion

- Add Oil Phase to Aqueous Phase slowly
- Stir to form uniform emulsion



Prepare Gel Base

- Disperse Xanthan Gum in water
- Hydrate completely
- Adjust pH with Triethanolamine



Combine Emulsion and Gel

- Slowly mix emulsion into gel base
- Stir gently until uniform Emulgel forms



Cool and Package

- Allow to cool
- Fill into containers

Evaluation Parameters

- **pH Measurement:** Using a calibrated pH meter to ensure the pH is within the physiological range of the skin to prevent irritation.
- **Viscosity:** Measured using a viscometer i.e. Brookfield viscometer to assess the flow properties and consistency, which impacts spreadability and retention on the skin.
- **Spreadability:** Determined by measuring the diameter of a spread circle of a known weight of emulgel between two glass plates. Good spreadability is crucial for patient compliance.
- **Extrudability:** Assessed by measuring the amount of emulgel extruded from a tube under specific pressure, indicating ease of application.

- **Homogeneity:** Visual inspection for the absence of lumps or aggregates, ensuring uniform distribution of ingredients.
- ❖ Skin Irritation and Sensitization Patch tests on healthy human volunteers to assess dermal safety, looking for erythema, edema, or other signs of irritation

Stability Parameters

- Temperature & Humidity Stress Testing – Evaluate physical and chemical stability over time.
- Phase Separation – Monitored for emulsion stability.
- pH and Viscosity Changes – Tracked periodically.

	Emulgels	Simple gels
Refrigerator temperature	E1,2,3	S1,2,3
25°C (in front of the sun)	E4,5,6	S4,5,6
30°C (protected from the sun)	E7,8,9	S7,8,9
40°C (protected from the sun)	E10,11,12	S10,11,12

Storage Conditions

Store emulgel in **cool, dry place away from direct sunlight in airtight containers** to preserve stability and prevent microbial growth.

Refrigeration can enhance stability for certain actives like kojic acid.

How to Use Emulgel

- Apply a thin layer to affected pigmented areas once or twice daily as directed.
- Gently massage until absorbed.
- Use sunscreen to prevent further UV-induced pigmentation.

Precautions

- Patch test recommended before first use.
 - Avoid contact with eyes and mucous membranes.
 - Discontinue if irritation or hypersensitivity occurs.
- Protect treated skin from UV exposure with sunscreen

CONCLUSION

Emulgels represent an advanced topically applied system ideal for antipigmentation therapy due to their unique blend of gel and emulsion properties, facilitating the delivery of hydrophobic plant extracts and other depigmenting agents.

With **improved permeability, patient compliance, and controlled release**, emulgels hold promise for both

cosmetic and therapeutic management of pigmentation disorders.

Emulgels are an advanced and versatile topical drug delivery system that effectively combines the benefits of gels and emulsions. They offer enhanced **penetration of hydrophobic and herbal actives**, improved **stability**, and **better patient compliance** compared to conventional creams or ointments.

Incorporating natural depigmenting agents like **liquorice, manjistha, and green tea extracts** into emulgels provides a promising approach for managing hyperpigmentation disorders, while also ensuring cosmetic acceptability.

With proper formulation, evaluation, and storage, antipigmentation emulgels can serve as an **efficient, safe, and cosmetically appealing option** for the treatment and prevention of skin pigmentation issues.

Conflict of interest: The authors have no conflict of interest.

Acknowledgements: The authors sincerely acknowledge the support and guidance provided by our mentors and faculty members during the completion of this review article.

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