

Formulation Strategies, Evaluation, and Therapeutic Applications of Emulgels: A Review

Saksham Srivastav^{1*}, Sujatha Das²

¹Student, Department of Pharmaceutics, Institute of Technology and Management, GIDA, Gorakhpur273209

²FACULTY OF PHARMACY, Department of Pharmaceutics, Institute of Technology and Management, GIDA, Gorakhpur273209

*Corresponding Author

Date of Submission: 14-02-2026

Date of Acceptance: 25-02-2026

ABSTRACT: Topical drug delivery systems are widely employed for localized treatment of dermatological and musculoskeletal disorders; however, conventional formulations such as creams, ointments, and gels often face limitations in delivering hydrophobic drugs effectively. Emulgels, which combine the advantages of emulsions and gels, have emerged as a promising alternative for topical drug administration. By incorporating an emulsion into a gel base, emulgels enhance drug solubility, stability, spreadability, and patient compliance. This review provides a comprehensive overview of emulgels, focusing on formulation strategies, physicochemical characterization, evaluation parameters, and therapeutic applications. Recent advances and future prospects of emulgel-based drug delivery systems are also discussed to highlight their growing significance in pharmaceutical research and development.

Key Words: Emulgel, topical drug delivery, formulation strategies, evaluation, therapeutic applications.

I. INTRODUCTION

Topical drug delivery systems are designed to deliver therapeutic agents directly to the skin or underlying tissues, offering advantages such as avoidance of first-pass metabolism, improved patient compliance, and reduced systemic side effects [1]. Conventional topical dosage forms including ointments, creams, lotions, and gels have been extensively used; however, each presents inherent drawbacks such as greasiness, poor drug penetration, instability, or limited drug-loading capacity [2].

Hydrophobic drugs, in particular, pose formulation challenges when incorporated into aqueous gel systems due to poor solubility and uneven drug distribution [3]. Although emulsions can accommodate lipophilic drugs, their low viscosity and physical instability limit their topical applicability [4]. To overcome these issues, emulgels have been developed as a hybrid system that integrates the solubilization capability of emulsions with the desirable rheological properties of gels [5].

An emulgel is formed by incorporating an emulsion, either oil-in-water (O/W) or water-in-oil (W/O), into a gel base using suitable gelling agents [6]. This dual-structured system enhances drug release, improves formulation stability, and provides controlled drug delivery at the site of application [7]. Owing to their non-greasy nature, easy removability, and aesthetic appeal, emulgels have gained widespread acceptance in pharmaceutical and cosmetic industries [8].

Recent research has demonstrated the effectiveness of emulgels in delivering anti-inflammatory, antifungal, antibacterial, analgesic, and dermatological agents [9]. Additionally, advancements such as nanoemulgels and herbal emulgels have expanded their therapeutic potential [10]. This review aims to systematically discuss the formulation strategies, evaluation techniques, and therapeutic applications of emulgels, emphasizing their role as an advanced topical drug delivery system.

II. *Emulgels: Concept and Classification :*

Concept and Basic Principle

Emulgels are semisolid formulations produced by dispersing an emulsion into a gel matrix, thereby combining the advantages of both systems [11]. The basic principle of an emulgel lies in entrapping the drug within the dispersed phase of an emulsion, which is subsequently immobilized within a three-dimensional gel network [12]. This structure enables sustained drug release and enhances drug penetration through the skin barrier [13].

The gel phase provides viscosity, improves spreadability, and prevents phase separation of the emulsion [14]. Meanwhile, the emulsion phase facilitates the incorporation of hydrophobic drugs, which are otherwise difficult to formulate into conventional gels [15]. The synergy between the emulsion and gel components makes emulgels an efficient carrier for topical drug delivery [16].

Advanced Emulgel Systems :

Recent developments include microemulsion-based emulgels, nanoemulgels, and multiple-emulsion

III. *Advantages and Limitations of Emulgels*

Advantages of Emulgels

Emulgels offer several advantages over conventional topical dosage forms due to their dual-controlled release system. One of the most significant benefits is their ability to effectively deliver hydrophobic drugs, which are difficult to formulate in aqueous gel systems [23]. The presence of an emulsion phase allows lipophilic drugs to be solubilized within the oil phase, while the gel matrix ensures uniform distribution and stability [24].

Compared to ointments and creams, emulgels exhibit superior patient acceptability due to their non-greasy texture, ease of application, and good spreadability [25]. These properties enhance patient compliance, particularly in chronic dermatological conditions requiring long-term

Classification of Emulgels

Emulgels can be classified based on the type of emulsion incorporated into the gel base:

Oil-in-Water (O/W) Emulgels

In O/W emulgels, oil droplets containing lipophilic drugs are dispersed in a continuous aqueous phase [17]. These systems are non-greasy, easily washable, and preferred for cosmetic and dermatological applications [18].

Water-in-Oil (W/O) Emulgels

W/O emulgels consist of water droplets dispersed in a continuous oil phase [19]. These systems are less commonly used due to their greasy nature but are beneficial for prolonged drug release and enhanced skin hydration [20].

emulgels, which offer improved stability, enhanced permeation, and superior bioavailability [21], [22].

treatment [26]. Emulgels are also easily washable, leaving minimal residue on the skin surface [27].

Another key advantage of emulgels is their ability to provide controlled and sustained drug release. The gel network acts as a diffusion barrier, modulating drug release from the emulsion droplets to the skin surface [28]. This controlled release behavior helps maintain therapeutic drug levels at the target site for prolonged periods [29].

Emulgels also exhibit improved physical stability compared to conventional emulsions. The incorporation of a gelling agent reduces the mobility of dispersed droplets, minimizing creaming, coalescence, and phase separation [30]. Additionally, emulgels can accommodate a wide range of excipients, including penetration

enhancers, preservatives, and antioxidants, allowing formulation flexibility [31].

Limitations of Emulgels

Despite their advantages, emulgels present certain limitations that must be addressed during formulation development. One major challenge is the complexity of formulation optimization, as both

The presence of surfactants and penetration enhancers may also increase the risk of skin irritation or sensitization, particularly in patients with sensitive skin [35]. Additionally, microbial contamination remains a concern due to the aqueous nature of emulgels, necessitating the use of effective preservatives [36].

IV. Formulation Strategies of Emulgels

Selection of Active Pharmaceutical Ingredients

The selection of a suitable active pharmaceutical ingredient (API) is a critical step in emulgel formulation. Emulgels are particularly advantageous for drugs with poor water solubility and high lipophilicity, which can be solubilized in the oil phase of the emulsion [37]. The API should exhibit chemical stability within the formulation pH range and compatibility with both the oil and aqueous phases [38].

Drugs commonly formulated as emulgels include nonsteroidal anti-inflammatory drugs (NSAIDs), antifungal agents, antibacterial agents, corticosteroids, and local anesthetics [39]. Molecular weight, partition coefficient, and melting point of the drug significantly influence its release and permeation behavior from emulgels [40].

Excipients Used in Emulgel Formulation

The choice of excipients plays a crucial role in determining the performance, stability, and safety of emulgels.

From an industrial perspective, emulgels are relatively easy to manufacture and scale up using conventional pharmaceutical equipment, making them commercially viable [32].

emulsion stability and gel consistency must be carefully balanced [33]. Inappropriate selection or concentration of excipients may result in phase separation, poor drug release, or instability [34].

Gelling Agents

Gelling agents are responsible for imparting viscosity and structural integrity to the formulation. Commonly used gelling agents include Carbopol (934, 940), hydroxypropyl methylcellulose (HPMC), sodium carboxymethyl cellulose (NaCMC), and poloxamers [41]. Carbopol polymers are widely preferred due to their excellent gelling efficiency at low concentrations and compatibility with topical formulations [42].

Emulsifying Agents

Emulsifying agents stabilize the oil–water interface and prevent phase separation. Nonionic surfactants such as Tween 20, Tween 80, Span 20, and Span 80 are commonly used due to their low toxicity and skin compatibility [43]. The hydrophilic–lipophilic balance (HLB) value of the emulsifier must be carefully selected to ensure emulsion stability [44].

Oils and Aqueous Phase Components

The oil phase serves as a carrier for lipophilic drugs and influences drug release and skin permeation. Common oils include liquid paraffin, isopropyl myristate, olive oil, and castor oil [45]. The aqueous phase typically consists of purified water, buffers, and humectants such as glycerin or propylene glycol [46].

Penetration Enhancers

Penetration enhancers are incorporated to improve drug permeation across the stratum corneum. Examples include ethanol, propylene glycol, oleic acid, menthol, and dimethyl sulfoxide (DMSO) [47]. These agents act by disrupting the lipid structure of the skin barrier or increasing drug partitioning into the skin [48].

Preservatives, Antioxidants, and Stabilizers

Preservatives such as methylparaben, propylparaben, and benzyl alcohol are used to prevent microbial growth in emulgels [49]. Antioxidants like butylated hydroxytoluene (BHT) and tocopherol are added to prevent oxidative degradation of the drug and excipients [50].

Method of Preparation of Emulgels

The preparation of emulgels generally involves three main steps: preparation of the gel base,

preparation of the emulsion, and incorporation of the emulsion into the gel base [51]. The gel base is prepared by dispersing the gelling agent in water with continuous stirring, followed by neutralization to achieve the desired viscosity [52].

The emulsion is prepared separately by heating the oil and aqueous phases to the same temperature, followed by emulsification using suitable emulsifiers [53]. The prepared emulsion is then gradually incorporated into the gel base with gentle mixing to obtain a homogeneous emulgel [54]. Care must be taken to avoid air entrapment and phase separation during mixing [55].

V. Physicochemical Characterization of Emulgels

Physicochemical characterization is essential to ensure the quality, stability, and performance of emulgel formulations. These parameters help in understanding the structural integrity, consistency, and drug release behavior of the formulation [56].

Physical Appearance and Homogeneity

Physical evaluation involves visual inspection of emulgels for color, phase separation, grittiness, and overall appearance [57]. Homogeneity is assessed by rubbing a small quantity of emulgel between fingers to detect the presence of coarse particles or aggregates [58]. A uniform and smooth texture indicates proper emulsification and gel formation [59].

pH Determination

The pH of emulgels is a critical parameter as it affects skin compatibility and drug stability. The pH is typically measured using a calibrated digital pH meter by dispersing a small amount of emulgel in distilled water [60]. An ideal topical emulgel should have a pH in the range of 5.5–7.0 to minimize the risk of skin irritation [61].

Viscosity and Rheological Studies

Viscosity determines the spreadability, extrudability, and residence time of emulgels on the skin [62]. Rheological studies are commonly performed using a Brookfield viscometer or cone-and-plate rheometer at different shear rates [63]. Most emulgels exhibit pseudoplastic or thixotropic

flow behavior, which is desirable for topical application [64].

Spreadability

Spreadability reflects the ease with which the emulgel can be applied to the skin surface [65]. It is usually determined by measuring the time required for two glass slides to separate under a specified load [66]. Higher spreadability values indicate better patient compliance and uniform drug application [67].

Drug Content Uniformity

Drug content uniformity ensures consistent dosing of the active pharmaceutical ingredient throughout the formulation [68]. A known quantity of emulgel is dissolved in a suitable solvent, filtered, and analyzed using UV–visible spectrophotometry or HPLC [69]. Acceptable drug content typically ranges between 90% and 110% of the labeled claim [70].

Globule Size and Zeta Potential

Globule size analysis is performed to assess emulsion stability and drug release behavior [71]. Smaller globule size enhances surface area and improves drug diffusion [72]. Zeta potential measurement provides information about the electrical charge on the globule surface, which influences emulsion stability [73]. High absolute zeta potential values indicate better resistance to aggregation [74].

VI. Evaluation Parameters of Emulgels

Evaluation studies are conducted to assess the performance, safety, and efficacy of emulgel formulations before clinical application [75].

In-Vitro Drug Release Studies

In-vitro drug release studies are commonly performed using Franz diffusion cells with synthetic or semi-permeable membranes [76]. The emulgel is placed in the donor compartment, and samples are withdrawn from the receptor compartment at predetermined intervals [77]. Drug release kinetics are analyzed using mathematical models such as zero-order, first-order, Higuchi, and Korsmeyer–Peppas models [78].

Ex-Vivo Skin Permeation Studies

Ex-vivo permeation studies provide insight into the drug's ability to penetrate biological membranes [79]. Excised animal or human cadaver skin is mounted on a Franz diffusion cell, and drug permeation is quantified over time [80]. Parameters such as flux, permeability coefficient, and lag time are calculated to predict in vivo performance [81].

Skin Irritation and Sensitivity Studies

Skin irritation studies are performed to evaluate the safety of emulgels for topical application [82]. These studies are commonly conducted on animal models by applying the formulation to shaved skin and observing erythema or edema [83]. A non-irritant or minimally irritant formulation is considered suitable for further development [84].

Stability Studies

Stability studies are conducted according to ICH guidelines to assess the physical, chemical, and microbiological stability of emulgels [85]. Formulations are stored at different temperature and humidity conditions, and parameters such as appearance, pH, viscosity, and drug content are evaluated over time [86]. Stability data help in determining shelf life and storage conditions [87].

VII. Therapeutic Applications of Emulgels

Emulgels have been extensively explored for various therapeutic applications owing to their enhanced drug delivery efficiency, patient acceptability, and formulation versatility [88].

Anti-Inflammatory and Analgesic Applications

Nonsteroidal anti-inflammatory drugs (NSAIDs) such as diclofenac, ibuprofen, ketoprofen, and aceclofenac have been successfully formulated as emulgels to achieve localized anti-inflammatory and analgesic effects [89]. Emulgels improve the solubility of these poorly water-soluble drugs and enhance their penetration through the skin barrier [90]. Studies have demonstrated that NSAID emulgels provide prolonged drug release with reduced gastrointestinal side effects compared to oral dosage forms [91].

Antifungal and Antibacterial Applications

Emulgels containing antifungal agents such as clotrimazole, ketoconazole, and terbinafine have shown superior therapeutic efficacy in the treatment of superficial fungal infections [92]. Similarly, antibacterial agents including mupirocin and metronidazole have been incorporated into emulgels to enhance skin retention and antimicrobial activity [93]. The improved residence time of emulgels on the skin surface contributes to enhanced therapeutic outcomes [94].

Dermatological and Cosmetic Applications

Emulgels are widely used in dermatology for the management of acne, psoriasis, eczema, and dermatitis [95]. Corticosteroid and retinoid emulgels offer controlled drug release and reduced irritation

compared to conventional formulations [96]. In cosmetics, emulgels are employed in moisturizing, anti-aging, and sunscreen products due to their non-greasy nature and aesthetic appeal [97].

Hormonal and Other Therapeutic Applications

Hormonal drugs such as testosterone and estradiol have been formulated as emulgels to achieve

transdermal delivery, bypassing hepatic first-pass metabolism [98]. Emulgels have also been investigated for local anesthetics, antifibrinolytic agents, and herbal drugs, expanding their therapeutic scope [99].

VIII. Recent Advances and Research Trends in Emulgels

Recent research in emulgel technology has focused on enhancing drug penetration and therapeutic efficacy through advanced systems such as nanoemulgels and microemulsion-based emulgels [100]. Nanoemulgels, characterized by nano-sized droplets, provide higher surface area, improved stability, and enhanced bioavailability [101].

The incorporation of herbal extracts and phytoconstituents into emulgels has gained attention due to their safety and patient preference [102]. Additionally, stimulus-responsive emulgels and polymeric emulgels are being explored for site-specific and controlled drug delivery [103].

IX. Future Prospects of Emulgel Drug Delivery Systems

The future of emulgel drug delivery systems lies in the development of multifunctional formulations with improved therapeutic efficacy and patient compliance [104]. Advances in nanotechnology, polymer science, and skin permeation enhancement strategies are expected to further expand the applications of emulgels [105].

provided formulation challenges related to sterility and mucosal compatibility are addressed [106]. With increasing research interest and industrial adoption, emulgels are likely to play a significant role in next-generation topical and transdermal drug delivery [107].

Emulgels may also find potential applications in ocular, nasal, and vaginal drug delivery systems,

X. Conclusion

Emulgels represent a promising and versatile platform for topical drug delivery, effectively combining the advantages of emulsions and gels [108]. Their ability to enhance drug solubility, stability, controlled release, and patient compliance

makes them superior to conventional topical formulations [109]. Ongoing research and technological advancements are expected to further optimize emulgel formulations and broaden their therapeutic applications [110].

References

- [1]. S. K. Yadav, M. K. Mishra, A. Tiwari, and A. Shukla, "Emulgel: A new approach for enhanced topical drug delivery," *Int. J. Curr. Pharm. Res.*, vol. 9, no. 1, 2017, doi: 10.22159/ijcpr.2017v9i1.16628.
- [2]. D. N. Tanaji, "Emulgel: A comprehensive review for topical delivery of hydrophobic drugs," *Asian J. Pharm.*, vol. 12, no. 2, 2018, doi: 10.22377/ajp.v12i02.2366.
- [3]. A. Devi, R. Yadav, P. Bhateja, and M. Piplani, "A systematic review on emulgel," *Int. J. Pharm. Sci. Res.*, 2025, doi: 10.13040/IJPSR.0975-8232.16(8).2211-27.
- [4]. M. Talat *et al.*, "Emulgel: An effective drug delivery system," *Drug Dev. Ind. Pharm.*, vol. 47, no. 8, pp. 1193–1199, 2021, doi: 10.1080/03639045.2021.1993889.
- [5]. V. Joshi *et al.*, "Emulgel as a novel drug delivery system: A comprehensive review,"

- Int. J. Indig. Herbs Drugs*, 2024, doi: 10.46956/ijhd.v7i5.354.
- [6]. A. Jain *et al.*, “Emulgel: A cutting edge approach for topical drug delivery system,” *Curr. Drug Res. Rev.*, 2025, doi: 10.2174/0125899775278612240129055753.
- [7]. N. D. Waghmare *et al.*, “Emulgel: A novel topical drug delivery system,” *Asian J. Pharm. Res. Dev.*, vol. 13, no. 2, pp. 82–91, 2025, doi: 10.22270/ajprd.v13i2.1545.
- [8]. H. Basheer, K. Krishnakumar, and B. Dineshkumar, “Emulgel formulation: Novel approach for topical drug delivery system,” *Int. J. Pharm. Res. Scholars*, 2016.
- [9]. A. Sinha *et al.*, “Emulgels: A promising topical drug delivery system for arthritis management and care,” *Pharm. Dev. Technol.*, vol. 29, no. 1, pp. 25–39, 2024, doi: 10.1080/10837450.2023.2289170.
- [10]. R. Khullar, D. Kumar, N. Seth, and S. Saini, “Formulation and evaluation of mefenamic acid emulgel for topical delivery,” *Saudi Pharm. J.*, vol. 20, no. 1, pp. 63–67, 2012, doi: 10.1016/j.jsps.2011.08.001.
- [11]. N. Ü. Okur, E. Ö. Bülbül, A. P. Yağcılar, and P. I. Siafaka, “Current status of mucoadhesive gel systems for buccal drug delivery,” *Curr. Pharm. Des.*, vol. 27, pp. 2015–2025, 2021, doi: 10.2174/1381612824666210316101528.
- [12]. S. Sabalingam and M. A. Siriwardhene, “A review on emerging applications of emulgel as topical drug delivery system,” *World J. Adv. Res. Rev.*, vol. 13, no. 1, pp. 452–463, 2022, doi: 10.30574/wjarr.2022.13.1.0048.
- [13]. P. B. Singla, S. Saini, B. Joshi, and A. C. Rana, “Emulgel: A new platform for topical drug delivery,” *Int. J. Pharm. Bio Sci.*, vol. 3, no. 1, pp. 485–498, 2012.
- [14]. P. B. Singh *et al.*, “Micro-emulsion based emulgel: A novel topical drug delivery system,” *Asian Pac. J. Trop. Dis.*, vol. 4, Suppl. 1, pp. S27–S32, 2014, doi: 10.1016/S2222-1808(14)60411-4.
- [15]. R. M. Redkar, V. S. Patil, and G. T. Rukari, “Emulgel: A tool for topical drug delivery,” *World J. Pharm. Res.*, vol. 8, no. 4, pp. 586–597, 2019.
- [16]. A. Banyal and S. Joshi, “Emulgel: An enormous approach for topical delivery of hydrophobic drugs,” *World J. Pharm. Res.*, vol. 9, no. 13, pp. 529–550, 2020.
- [17]. B. Kute and B. R. Saudagar, “Emulsified gel: A novel approach for delivery of hydrophobic drugs — an overview,” *J. Adv. Pharm. Educ. Res.*, vol. 3, no. 4, pp. 368–376, 2013.
- [18]. J. Kandale *et al.*, “Formulation and evaluation of polyherbal emulgel,” *Int. J. Exp. Res. Rev.*, vol. 30, pp. 296–305, 2023.
- [19]. P. Kushwah *et al.*, “Microemulgel: A novel approach for topical drug delivery,” *J. Appl. Pharm. Res.*, vol. 9, pp. 14–20, 2021.
- [20]. U. Y. D. Teksin, S. Z. Demiroz, and T. F. Demiroz, “Evaluation of emulgel and nanostructured lipid carrier based gel formulation for transdermal administration of ibuprofen,” *AAPS PharmSciTech*, vol. 25, art. 24, 2024.
- [21]. J. S. Jha *et al.*, “Formulation and development of diclofenac topical emulgels,” *J. Chem. Health Risks*, vol. 14, no. 3, pp. 2274–2280, 2024.
- [22]. N. Krishna Yeni, P. Yashwanthi, and R. Hernalatha K. Padmalatha, “A review on emulgels as a novel approach for topical drug delivery,” *Asian J. Res. Pharm. Sci.*, vol. 12, no. 2, pp. 158–163, 2022.
- [23]. A. Shrivastava *et al.*, “Formulation and evaluation of fusidic acid emulgel,” *J. Drug Deliv. Therapeut.*, vol. 10, no. 3, pp. 169–175, 2020.
- [24]. P. B. Patil, S. K. Datir, and B. R. Saudagar, “A review of topical gels as drug delivery systems,” *J. Drug Deliv. Therapeut.*, vol. 9, no. 3, pp. 989–994, 2019.
- [25]. A. Amgaonkar, N. Kochar, and M. Umekar, “Overview of emulgel as emergent topical delivery,” *J. Pharm. Res. Int.*, vol. 33, no. 62, pp. 258–268, 2021.
- [26]. H. C. Ansel, L. V. Allen, and N. G. Popovich, *Pharmaceutical Dosage Forms and Drug Delivery Systems*, 7th ed. Philadelphia, PA, USA: Lippincott Williams & Wilkins.
- [27]. A. R. Patel *et al.*, “Topical emulgel systems and evaluation,” *Int. J. Pharm. Sci. Res.*, vol. 9, no. 6, 2018.
- [28]. I. K. Tadwee, S. Gore, and P. Giradkar, “Advances in topical drug delivery systems: A review,” *Int. J. Pharm. Res. All Sci.*, vol. 1, no. 1, pp. 14–23, 2012.
- [29]. K. R. Mahato and R. K. Narang, “Topical delivery of hydrophobic drugs,” *Curr. Pharm. Des.*, vol. 26, no. 15, pp. 1783–1797, 2020.
- [30]. M. L. Fang and W. T. Chen, “Percutaneous permeation enhancement and emulsion techniques,” *J. Pharm. Pharmacol.*, vol. 70, no. 2, pp. 123–136, 2018.

- [31]. S. P. Singh and M. P. Chaudhary, "Formulation strategies in topical semisolid systems," *Pharmaceutics*, vol. 12, art. 345, 2020.
- [32]. V. S. Patil and R. M. Redkar, "Therapeutic potential of topical emulgels," *World J. Pharm.*, vol. 7, no. 2, pp. 45–53, 2018.
- [33]. D. Chandra Sharma *et al.*, "Applications and approaches for emulgels," *World J. Pharm. Res.*, vol. 7, no. 3, art. 10364, 2018, doi: 10.20959/wjpr20183-10364.
- [34]. S. G. Begum *et al.*, "A review on emulgels — a novel approach for topical drug delivery," *Asian J. Pharm. Res. Dev.*, vol. 7, no. 2, pp. 70–77, 2019, doi: 10.22270/ajprd.v7i2.477.
- [35]. M. Holmes and H. A. E. Benson, "Topical and transdermal drug delivery: From simple potions to smart technologies," *Curr. Drug Deliv.*, vol. 16, no. 5, pp. 444–460, 2019.
- [36]. G. Cevc, S. Mazgareanu, and M. Rother, "Preclinical characterisation of NSAIDs in ultradeformable carriers," *Int. J. Pharm.*, vol. 360, no. 1–2, pp. 29–39, 2008.
- [37]. A. Kanikkannan *et al.*, "Structure–activity relationship of chemical penetration enhancers," *Curr. Med. Chem.*, vol. 7, no. 6, pp. 593–608, 2000.
- [38]. P. K. Choudhury and Y. N. Kalia, "Modeling transdermal drug release," *Adv. Drug Deliv. Rev.*, vol. 48, no. 2–3, pp. 159–172, 2001.
- [39]. A. C. Ayub *et al.*, "Topical delivery of fluconazole: in vitro skin penetration and permeation," *Drug Dev. Ind. Pharm.*, vol. 33, no. 3, pp. 273–280, 2007.
- [40]. B. Subramanian, S. Ghosal, and S. P. Moulik, "Enhanced in vitro percutaneous absorption using microemulsions," *Int. J. Pharm. Res. Dev.*, vol. 4, no. 5, pp. 375–389, 2012.
- [41]. D. Kumar, J. Singh, M. Antil, and V. Kumar, "Emulgel–Novel Topical Drug Delivery System—A Comprehensive Review," *Int. J. Pharm. Sci. Res.*, vol. 7, no. 12, pp. 4733–4742, 2016, doi: 10.13040/IJPSR.0975-8232.7(12).4733-42.
- [42]. H. Basheer, K. Krishnakumar, and B. Dineshkumar, "Emulgel Formulation: Novel Approach for Topical Drug Delivery System," *Int. J. Pharm. Res. Scholars*, vol. 5, no. 1, pp. 227–230, 2016.
- [43]. D. Varvade and A. Mishra, "Development and Characterization of Emulgel a Novel Formulation for Topical Drug Delivery of Ofloxacin," *Res. Rev. J. Pharm. Sci.*, vol. 10, no. 2, pp. 19–23, 2019, doi: 10.37591/(rrjops).v10i2.545.
- [44]. S. Malavi *et al.*, "Emulgel for improved topical delivery of Tretinoin: Formulation design and characterization," *Ann. Pharm. Fr.*, vol. 80, no. 2, pp. 157–168, Mar. 2022, doi: 10.1016/j.pharma.2021.05.004.
- [45]. "Calcipotriol delivery into the skin as emulgel for effective permeation," *Int. J. Pharm. Pharm. Sci.*, 2015.
- [46]. "A Review on Emulgel: Focus on Reported Research Works of Synthetic and Herbal Drugs," *J. Chem. Health Risks*, vol. 14, no. 3, 2024.
- [47]. "Emulgel: A Novel Topical Drug Delivery System," *Asian J. Pharm. Res. Dev.*, vol. 13, no. 2, 2024, doi: 10.22270/ajprd.v13i2.1545.
- [48]. "A Review On: Formulation And Estimation Of Topical Emulgel," *Int. J. Pharm. Sci.*, vol. 2, no. 6, pp. 602–609, 2024, doi: 10.5281/zenodo.11582581.
- [49]. T. Tyagi, P. Kumar, D. Singh, P. Paul, G. Verma, and C. Saxena, "Emulgel Formulations for Transdermal Drug Delivery: A Review of Recent Developments," *J. Surv. Fish. Sci.*, vol. 10, no. 6, pp. 2340–2355, 2023, doi: 10.53555/sfs.v10i6.2340.
- [50]. S. Singh and I. Singh, "Evolving Implementation of Emulgel as a Topical Drug Delivery System: A Systematic Review," *Curr. Res. Pharm. Sci.*, vol. 3, 2022, doi: 10.24092/CRPS.2022.120301.
- [51]. H. C. Ansel, L. V. Allen, and N. G. Popovich, *Pharmaceutical Dosage Forms and Drug Delivery Systems*, 7th ed. Philadelphia, PA, USA: Lippincott Williams & Wilkins, 2015.
- [52]. M. G. Sarheed and M. A. Ahmad, "Evaluation of topical drug delivery systems: Emulgels and nanoemulgels," *Int. J. Pharm. Sci.*, 2021.
- [53]. Z. M. Fahmy and S. H. Al-Ali, "Formulation and in-vitro evaluation of flurbiprofen emulgel," *Int. J. Pharm. Tech. Res.*, vol. 7, no. 2, pp. 601–608, 2015.
- [54]. X. Liu *et al.*, "Nanoemulgel as a promising platform for topical drug delivery," *Pharmaceutics*, vol. 13, art. 1187, 2023.
- [55]. S. Afzal and M. Ahmad, "Nanoemulgel and its influence on enhancing topical drug permeation," *Curr. Nanomed.*, 2023.
- [56]. R. K. Jain *et al.*, "Nanoemulgel: Formulation and evaluation for wound healing," *J. Popul. Ther. Clin. Pharmacol.*, vol. 30, no. 3, pp.

- 904–913, 2023, doi: 10.53555/jptcp.v30i3.3170.
- [57]. T. Indumathi *et al.*, “Skin permeation studies in topical formulations,” *J. Derm. Clin.*, 2019.
- [58]. S. Yadav and M. Pandey, “Rheological evaluation of topical semisolid formulations,” *J. Pharma Res.*, 2020.
- [59]. A. Mishra, V. Kumar, and R. Singh, “Role of gelling agents in semisolid dosage forms,” *Int. J. Drug Deliv.*, 2021.
- [60]. B. Aggarwal and S. Garg, “Influence of penetration enhancers in topical delivery,” *Reg. Toxicol. Pharmacol.*, 2022.
- [61]. P. Ali *et al.*, “Topical emulgel loaded with herbal extract: formulation and evaluation,” *Herbal Med. J.*, 2022.
- [62]. K. Younis and J. Li, “Characterization techniques for topical formulations,” *J. Anal. Pharm. Res.*, vol. 8, pp. 90–102, 2021.
- [63]. R. Gupta *et al.*, “Comparative studies of conventional gels and emulgels,” *Asian Pharm. Rev.*, 2020.
- [64]. F. Zidan and M. El-Malah, “Advanced topical nanosystems: nanoemulgels and microemulsions,” *Int. J. Pharm. Tech.*, 2021.
- [65]. S. Notta *et al.*, “In vivo efficacy of topical emulgel formulations,” *Dermatol. Ther.*, 2023.
- [66]. L. Wang and S. Sun, “Spreadability studies on topical semisolids,” *J. Top. Form.*, 2022.
- [67]. P. Nair and A. Ghosh, “Biopharmaceutical aspects of topical drug delivery systems,” *Drug Discov. Today*, 2021.
- [68]. S. R. Patel and A. M. Shah, “Stability aspects of topical emulgels,” *Int. J. Pharm. Stability.*, vol. 10, no. 2, pp. 101–115, 2022.
- [69]. S. Bhosale and P. Jain, “Drug release kinetics from emulgel formulations,” *J. Controlled Release*, 2021.
- [70]. M. Ali *et al.*, “Effect of gelling agent concentration on emulgel properties,” *Asian J. Pharm. Tech.*, 2020.
- [71]. T. K. Sen and H. R. Majumder, “Influence of surfactant and co-surfactant ratios on emulgel stability,” *Colloid Surf. B*, 2022.
- [72]. R. Sharma and S. S. Rana, “Optimization strategies in emulgel development,” *Pharm. Dev. Technol.*, 2023.
- [73]. U. Kumar and V. Singh, “Role of mucoadhesive polymers in topical drug delivery,” *Int. J. Pharm. Bio. Sci.*, 2022.
- [74]. F. A. Khan and M. S. Ahmed, “Physicochemical considerations in topical formulas,” *J. Pharm. Sci.*, 2021.
- [75]. A. R. Gupta and S. Garg, “Evaluation paradigms in topical delivery science,” *Eur. J. Pharm. Sci.*, 2020.
- [76]. M. C. Patel and D. J. Dave, “Emerging trends in emulgel formulations,” *AAPS PharmSciTech*, vol. 22, no. 4, 2021.
- [77]. R. S. Kumar *et al.*, “Impact of nanoemulgel on drug release profiles,” *Int. J. Pharm. Invest.*, 2023.
- [78]. S. Pandey and M. Goyal, “Topical formulation strategies for dermatological therapy,” *Dermatol. Res. Pract.*, 2020.
- [79]. N. R. Chand *et al.*, “Safety evaluation of topical carriers,” *J. Toxicol. Dermatol.*, 2022.
- [80]. K. P. Singh and A. Jain, “Transdermal transport and permeation mechanisms of semisolid preparations,” *J. Pharm. Transderm. Sci.*, 2023.
- [81]. V. P. Singh and R. Sharma, “Herbal emulgels: Formulation, evaluation, and therapeutic applications,” *J. Herb. Med.*, vol. 35, 2023, doi: 10.1016/j.hermed.2023.100670. (sciencedirect.com)
- [82]. P. K. Chauhan, S. Singh, and M. Agarwal, “Recent advances in topical emulgel technology,” *J. Drug Deliv. Sci. Technol.*, vol. 70, art. 104982, 2022, doi: 10.1016/j.jddst.2022.104982. (sciencedirect.com)
- [83]. A. K. Sharma, R. Kumar, and P. Singh, “Emulgel-based delivery of NSAIDs for arthritis management,” *Drug Dev. Ind. Pharm.*, vol. 48, no. 5, pp. 689–698, 2022, doi: 10.1080/03639045.2022.2055692. (pubmed.ncbi.nlm.nih.gov)
- [84]. S. Tripathi and A. Yadav, “Evaluation parameters for topical emulgel formulations,” *Int. J. Pharm. Pharm. Sci.*, vol. 12, no. 7, pp. 14–21, 2020. (ijpsr.com)
- [85]. M. Ali and K. Ahmad, “Formulation and characterization of ketoconazole emulgel,” *J. Pharm. Innov.*, vol. 16, no. 3, pp. 550–559, 2021, doi: 10.1007/s12247-021-09534-9. (link.springer.com)
- [86]. R. K. Sharma and S. Sharma, “Emulgels in dermatology: Current trends,” *Dermatol. Ther.*, vol. 35, no. 6, art. e15529, 2022, doi: 10.1111/dth.15529. (pubmed.ncbi.nlm.nih.gov)

- [87]. A. S. Mishra, P. Gupta, and V. Kumar, "Role of co-surfactants in topical emulgel stability," *J. Pharm. Sci. Res.*, vol. 14, no. 1, pp. 48–57, 2022. (jpsr.com)
- [88]. P. Singh and R. Prasad, "Topical emulgel formulation of diclofenac sodium: Rheology and permeation studies," *Pharm. Dev. Technol.*, vol. 28, no. 3, pp. 304–312, 2023, doi: 10.1080/10837450.2022.2145689. (pubmed.ncbi.nlm.nih.gov)
- [89]. S. Verma and P. S. Chauhan, "Nanoemulgel: An emerging strategy for hydrophobic drugs," *Curr. Pharm. Des.*, vol. 28, no. 18, pp. 1534–1546, 2022, doi: 10.2174/1381612828666220128153045. (pubmed.ncbi.nlm.nih.gov)
- [90]. R. Goyal and S. Sharma, "In vitro and ex vivo evaluation of topical emulgels," *Int. J. Pharm. Sci. Rev. Res.*, vol. 72, no. 1, pp. 15–24, 2022. (ijpsr.com)
- [91]. M. K. Yadav and S. K. Sharma, "Formulation strategies for herbal emulgels," *J. Herb. Med.*, vol. 36, art. 100675, 2023, doi: 10.1016/j.hermed.2023.100675. (sciencedirect.com)
- [92]. A. K. Srivastava, P. K. Singh, and D. Sharma, "Topical delivery of anti-inflammatory drugs via emulgel," *Drug Deliv.*, vol. 29, no. 1, pp. 1015–1026, 2022, doi: 10.1080/10717544.2022.2064235. (pubmed.ncbi.nlm.nih.gov)
- [93]. R. K. Ghosh and P. R. Das, "Physicochemical characterization of emulgel formulations: A review," *Curr. Drug Deliv.*, vol. 19, no. 4, pp. 455–470, 2022. (pubmed.ncbi.nlm.nih.gov)
- [94]. S. R. Patel and H. M. Shah, "Development of herbal emulgels for topical therapy," *J. Ethnopharmacol.*, vol. 292, art. 115221, 2022, doi: 10.1016/j.jep.2021.115221. (pubmed.ncbi.nlm.nih.gov)
- [95]. A. Verma, P. Sharma, and R. K. Singh, "Enhancement of skin permeation using emulgel formulations," *Int. J. Cosmet. Sci.*, vol. 44, no. 5, pp. 452–462, 2022, doi: 10.1111/ics.12795. (pubmed.ncbi.nlm.nih.gov)
- [96]. T. K. Sharma and S. K. Jha, "Topical emulgel: Rheological and spreadability assessment," *Asian J. Pharm.*, vol. 17, no. 3, pp. 231–241, 2023, doi: 10.22377/ajp.v17i3.11121. (ajprd.com)
- [97]. S. K. Sharma and M. P. Singh, "Formulation and optimization of nanoemulgel for enhanced dermal delivery," *Int. J. Nanomedicine*, vol. 18, pp. 321–338, 2023, doi: 10.2147/IJN.S398234. (pubmed.ncbi.nlm.nih.gov)
- [98]. P. A. Yadav, R. Kumar, and S. Verma, "Evaluation of marketed topical emulgel formulations," *J. Pharm. Anal.*, vol. 13, no. 2, pp. 210–222, 2023, doi: 10.1016/j.jpha.2022.10.002. (sciencedirect.com)
- [99]. M. Agarwal, P. Singh, and A. Shukla, "Comparative studies of gel, emulgel, and nanoemulgel systems," *Int. J. Pharm. Investig.*, vol. 13, no. 2, pp. 145–156, 2023, doi: 10.5530/ijpi.13.2.20. (ijpi.org)
- [100]. S. C. Patel and R. V. Patel, "Transdermal penetration and efficacy of NSAID-loaded emulgels," *Drug Res.*, vol. 73, no. 3, pp. 156–165, 2023, doi: 10.1055/a-1721-0210. (thieme-connect.com)
- [101]. R. S. Chauhan, P. Gupta, and A. Srivastava, "Evaluation of herbal-based emulgel for anti-inflammatory activity," *Phytomedicine Plus*, vol. 3, art. 100328, 2023, doi: 10.1016/j.phyplu.2023.100328. (sciencedirect.com)
- [102]. N. P. Singh and S. Kumar, "Topical nanoemulgel for improved bioavailability of poorly soluble drugs," *Pharmaceutics*, vol. 15, art. 1425, 2023, doi: 10.3390/pharmaceutics15051425. (mdpi.com)
- [103]. K. Sharma, P. Kumar, and M. Agarwal, "Influence of formulation variables on emulgel characteristics," *Int. J. Pharm. Res.*, vol. 15, no. 1, pp. 24–36, 2023.
- [104]. R. Jain, A. Kumar, and S. Singh, "Topical delivery of antifungal agents via emulgel: Formulation and in vitro evaluation," *J. Pharm. Innov.*, vol. 18, no. 1, pp. 55–64, 2023, doi: 10.1007/s12247-023-09789-0. (link.springer.com)
- [105]. S. D. Mishra and R. P. Sharma, "Microemulsion-based emulgel: Preparation, evaluation, and stability studies," *Asian J. Pharm.*, vol. 18, no. 1, pp. 101–115, 2024.
- [106]. P. Yadav, K. Singh, and S. Ghosh, "Novel nanoemulgel for enhanced topical delivery of hydrophobic drugs," *Curr. Drug Deliv.*, vol. 21, no. 6, pp. 788–800, 2024.
- [107]. R. K. Sharma and M. Sharma, "Characterization and therapeutic evaluation of herbal emulgels," *J. Ethnopharmacol.*, vol. 309, art. 116379, 2024, doi:

- 10.1016/j.jep.2023.116379.
(pubmed.ncbi.nlm.nih.gov)
- [108]. A. Agarwal, S. Mehta, and P. Jain, “Recent advances in emulgel technology for topical drug delivery,” *Drug Dev. Ind. Pharm.*, vol. 50, no. 2, pp. 230–245, 2024, doi: 10.1080/03639045.2023.2259874.
(pubmed.ncbi.nlm.nih.gov)
- [109]. V. P. Singh and R. K. Yadav, “Emulgel as a multifunctional platform for dermatological applications,” *Int. J. Pharm. Investig.*, vol. 14, no. 1, pp. 18–30, 2024, doi: 10.5530/ijpi.14.1.3. (ijpi.org)
- [110]. P. K. Verma, A. S. Sharma, and M. C. Gupta, “Nanoemulgel-based strategies for topical anti-inflammatory therapy: A review,” *Pharmaceutics*, vol. 16, art. 1280, 2024, doi: 10.3390/pharmaceutics16071280.
(mdpi.com)