Advances in Bioresearch
Adv. Biores., Vol 17 (6) June 2026: 01-09

Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.17.6.19

Advances in Bioresearch

REVIEW ARTICLE

Nanoemulgel: A Novel Nanocarrier as a Tool for Topical Drug Delivery – Current Advances, Challenges, and Future Prospects

Rohan Wathore, Ganesh Shevalkar and Laxmikant Borse
Department of Pharmaceutics, Sandip Institute of Pharmaceutical Science, Nashik – 422213 Maharashtra, India
***Corresponding Author:** Ganesh B. Shevalkar
Email: ganeshshevakar@gmail.com
ORCHID ID: 0000-0003-4027-9002

ABSTRACT
Nanoemulgel is an emerging hybrid drug delivery system that integrates the advantages of nanoemulsion and gel-based formulations, offering a promising platform for topical drug delivery. The increasing prevalence of lipophilic drug candidates with poor aqueous solubility and bioavailability has driven the development of advanced nanocarrier systems. Nanoemulgels provide enhanced drug permeation, improved stability, controlled release, and better patient compliance compared to conventional dosage forms. This review comprehensively discusses the formulation strategies, physicochemical properties, mechanisms of drug permeation, evaluation parameters, and therapeutic applications of nanoemulgels. Special emphasis is placed on novel approaches such as stimuli-responsive nanoemulgels, targeted delivery systems, and incorporation of nanostructured carriers within gel matrices. Recent advancements highlight the potential of nanoemulgels in treating dermatological disorders, wound healing, infections, cancer, and transdermal drug delivery. The integration of nanotechnology with polymer science has significantly improved drug delivery efficiency by overcoming the stratum corneum barrier. Furthermore, this review explores current challenges such as stability issues, scale-up limitations, and regulatory considerations. Future prospects include personalized medicine, smart delivery systems, and artificial intelligence-assisted formulation design. Nanoemulgels represent a versatile and innovative platform with significant potential for commercialization and clinical translation in topical therapeutics.
Keywords*: Nanoemulgel, Nanoemulsion, Topical Drug Delivery, Nanocarriers, Skin Permeation, Controlled Release, Lipophilic Drugs*

Received 24.04.2026 Revised 01.05.2026 Accepted 01.06.2026

How to cite this article:
Rohan W, Ganesh S, Laxmikant B. Nanoemulgel: A Novel Nanocarrier as a Tool for Topical Drug Delivery – Current Advances, Challenges, and Future Prospects. Adv. Biores. Vol 17 [6] June 2026. 01-09

INTRODUCTION

The pharmaceutical industry is currently facing a major challenge due to the increasing number of newly discovered drug molecules exhibiting poor aqueous solubility. It is estimated that nearly 40–90% of newly developed drugs are lipophilic in nature, leading to low bioavailability and poor therapeutic efficacy [1-3]. Topical drug delivery has emerged as a highly advantageous route of administration due to its non-invasive nature, localized therapeutic action, reduced systemic side effects, and improved patient compliance. Over the past few decades, there has been significant advancement in the design and development of novel drug delivery systems aimed at overcoming the limitations associated with conventional topical formulations such as creams, ointments, and lotions. Despite their widespread use, these traditional dosage forms often suffer from poor drug penetration, low bioavailability, instability, and patient inconvenience due to greasiness or poor spreadability. These challenges have driven the exploration of advanced carrier systems, among which nano-based formulations have gained remarkable attention [4]. Nanotechnology has revolutionized pharmaceutical sciences by enabling the development of delivery systems at the nanoscale, typically ranging from 10 to 1000 nanometers. These nanocarriers exhibit unique physicochemical properties, including a large surface area-to-volume ratio, enhanced solubility of poorly water-soluble drugs, improved stability, and the ability to modulate drug release.

Among various nanocarrier systems such as liposomes, solid lipid nanoparticles, nanostructured lipid carriers, and polymeric nanoparticles, nanoemulsions have emerged as a promising platform for topical drug delivery [5, 6].

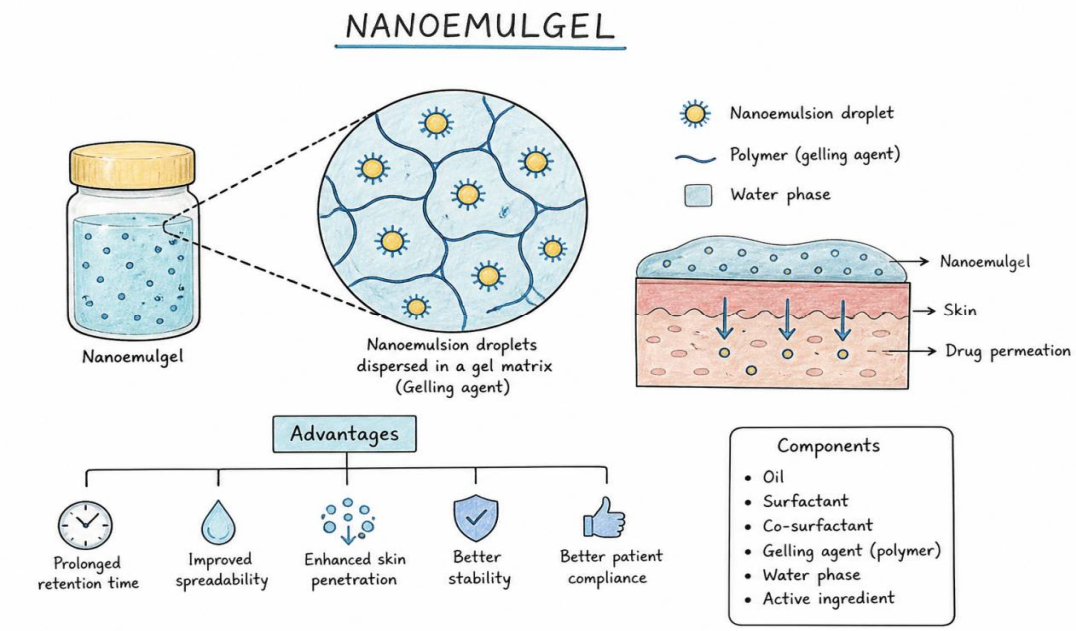

Fig 1: Nanoemulgel: Structure, Components, and Mechanism of Drug Delivery

Nanoemulsions are thermodynamically or kinetically stable colloidal dispersions composed of oil, water, surfactants, and often co-surfactants, with droplet sizes typically in the nanometer range. These systems offer several advantages, including enhanced drug solubilization, improved skin permeation, and controlled drug release [7-9]. The small droplet size facilitates closer contact with the stratum corneum, the outermost layer of the skin, thereby enhancing drug penetration. Additionally, the presence of surfactants can disrupt the lipid structure of the stratum corneum, further promoting drug absorption [5]. However, despite their advantages, nanoemulsions possess certain limitations when used alone for topical application. Their low viscosity can lead to poor retention at the site of application, resulting in rapid runoff and reduced residence time. This can ultimately compromise therapeutic efficacy. To address this issue, researchers have developed nanoemulgel systems, which combine the benefits of nanoemulsions with those of gels. Nanoemulgel is an advanced drug delivery system in which a nanoemulsion is incorporated into a gel matrix [10-13]. This hybrid system merges the high drug loading capacity and enhanced permeation properties of nanoemulsions with the favorable rheological properties, ease of application, and improved patient acceptability of gels. The gel phase provides increased viscosity, thereby improving the formulation's adherence to the skin and prolonging the residence time of the drug at the application site. This results in sustained drug release and enhanced therapeutic outcomes. The skin, being the largest organ of the human body, serves as a protective barrier against external environmental factors. Its complex structure, comprising the epidermis, dermis, and hypodermis, presents significant challenges for drug delivery. The primary barrier to drug penetration is the stratum corneum, which consists of densely packed corneocytes embedded in a lipid matrix. This "brick-and-mortar" structure restricts the permeation of most drugs, particularly hydrophilic and high molecular weight compounds [14]. Therefore, overcoming this barrier is a critical aspect of designing effective topical formulations. Nanoemulgels offer a strategic advantage in this regard. The nanosized droplets enhance drug diffusion through the stratum corneum, while the gel base ensures prolonged contact with the skin surface. Additionally, the formulation components, such as surfactants and oils, can act as permeation enhancers by altering the lipid structure of the skin. This synergistic effect significantly improves drug bioavailability at the target site. Another important aspect of nanoemulgel systems is their ability to deliver both hydrophilic and lipophilic drugs effectively [15]. The oil phase of the nanoemulsion can solubilize lipophilic drugs, while the aqueous phase can accommodate hydrophilic compounds. This versatility makes nanoemulgels suitable for a wide range of therapeutic agents, including anti-inflammatory drugs, antifungals, antivirals, analgesics, and cosmetic actives [16]. The formulation of nanoemulgels involves careful selection of components such as oils, surfactants, co-surfactants, gelling

agents, and aqueous phase. The choice of oil is critical as it influences drug solubility and permeation. Commonly used oils include natural oils, medium-chain triglycerides, and synthetic esters. Surfactants and co-surfactants play a vital role in stabilizing the nanoemulsion and reducing interfacial tension. Gelling agents such as carbopol, hydroxypropyl methylcellulose (HPMC), and xanthan gum are used to impart the desired viscosity and consistency to the formulation [17]. The preparation of nanoemulgels typically involves two main steps: the formation of nanoemulsion followed by its incorporation into the gel base [18]. Nanoemulsions can be prepared using high-energy methods such as high-pressure homogenization, ultrasonication, and microfluidization, or low-energy methods such as phase inversion temperature and spontaneous emulsification. Once the nanoemulsion is formed, it is mixed with the gel base under controlled conditions to obtain a uniform nanoemulgel [19]. Characterization of nanoemulgels is essential to ensure their quality, stability, and performance. Key parameters include droplet size, polydispersity index, zeta potential, viscosity, pH, spreadability, drug content, and in vitro drug release. Stability studies are also conducted to evaluate the formulation's physical and chemical stability under different storage conditions. Advanced techniques such as scanning electron microscopy and transmission electron microscopy can be used to analyze the morphology of the nanoemulsion droplets. In recent years, nanoemulgels have gained significant attention in both pharmaceutical and cosmetic applications. In the pharmaceutical field, they are widely explored for the treatment of dermatological conditions such as acne, psoriasis, fungal infections, and inflammation. Their ability to enhance drug penetration and provide controlled release makes them particularly suitable for chronic conditions requiring prolonged therapy [20-24]. In the cosmetic industry, nanoemulgels are used in products such as moisturizers, sunscreens, anti-aging creams, and skin-lightening formulations due to their improved texture, stability, and efficacy [25]. Furthermore, nanoemulgels have shown potential in delivering drugs for systemic action via transdermal routes. By facilitating drug absorption through the skin into the systemic circulation, they can bypass first-pass metabolism and improve bioavailability. This approach is particularly beneficial for drugs with poor oral bioavailability or those associated with gastrointestinal side effects. Despite their numerous advantages, nanoemulgel systems also face certain challenges. These include the potential for skin irritation due to high surfactant concentration, stability issues related to phase separation or droplet aggregation, and the complexity of formulation development. Additionally, large-scale manufacturing and regulatory considerations can pose hurdles in the commercialization of nanoemulgel products. Therefore, ongoing research is focused on optimizing formulation strategies, improving stability, and ensuring safety and efficacy.

The integration of nanotechnology with conventional gel systems represents a significant advancement in topical drug delivery. Nanoemulgels provide a promising platform for enhancing drug solubility, stability, and bioavailability while ensuring patient convenience and compliance. Their versatility and effectiveness make them an attractive option for both pharmaceutical and cosmetic applications. In conclusion, nanoemulgel systems have emerged as a novel and efficient nanocarrier for topical drug delivery. By combining the advantages of nanoemulsions and gels, they address the limitations of conventional formulations and offer improved therapeutic outcomes. Continued research and development in this field are expected to further expand their applications and pave the way for innovative drug delivery solutions [26-28].

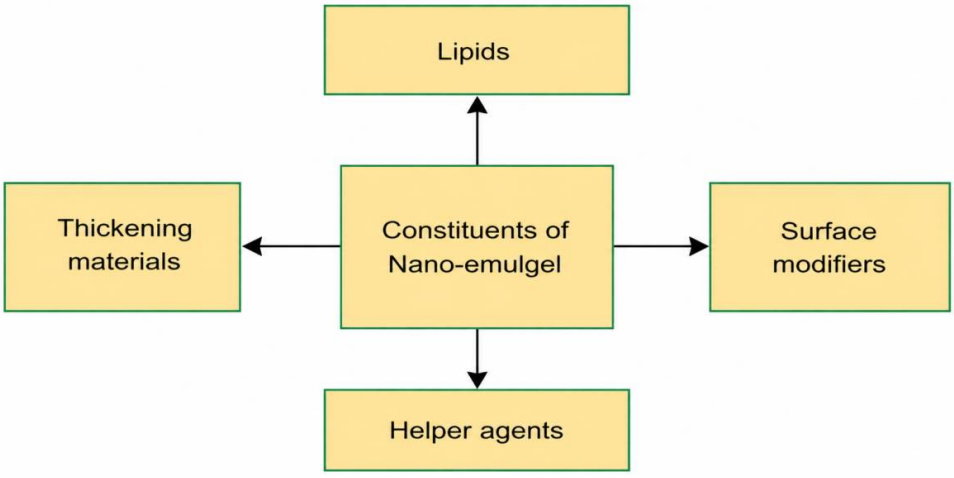

Fig 2 : Constituents of Nano-Emulgel Formulation

NANO-EMULSIONS

Nano-emulsions are colloidal systems composed of two immiscible liquids, typically oil and water, where one phase is finely dispersed within the other. These systems consist of a dispersed phase and a continuous phase, and their stability is maintained with the help of emulsifying agents that lower the interfacial tension between the two phases. One of the key features of nano-emulsions is their improved stability compared to conventional emulsions, which contributes to a longer shelf life and better performance in various formulations. Their small droplet size enhances surface area, which can improve drug delivery and absorption. Despite these advantages, nano-emulsions also present certain drawbacks. They generally possess low viscosity, which can result in reduced residence time at the site of application. Additionally, their spreadability may be limited, making them less suitable for topical use in some cases. To overcome these limitations, nano-emulsions can be transformed into nano-emulgels by incorporating appropriate gelling agents. This modification improves viscosity, enhances retention at the application site, and provides better consistency for topical delivery [29-34].

Nano-emulgel

Although nano-emulsions offer several benefits, their practical use especially in topical and clinical applications is limited by low viscosity, which leads to poor spreadability and short residence time at the site of application. To address these drawbacks, nano-emulsions can be converted into nano-emulgels through the incorporation of suitable gelling agents. A nano-emulgel is formed when a nano-emulsion is embedded within a gel matrix, typically prepared using aqueous or hydroalcoholic bases containing polymeric substances. These polymers absorb liquid, swell, and create a three-dimensional network that provides the system with semisolid consistency. This transformation enhances the physical stability of the formulation while maintaining the beneficial properties of the nano-emulsion. Nano-emulgels function as controlled-release systems for topical drug delivery. They are particularly useful for drugs with short biological half-lives, as the gel structure prolongs the contact time with the skin and allows gradual drug release. The incorporation of a nano-emulsion into a gel base also helps to improve formulation stability and reduce issues associated with phase separation [35].

In terms of performance, nano-emulgels combine the advantages of both gels and nano-emulsions. They retain the small droplet size and improved stability of nano-emulsions, while offering better viscosity and ease of application due to the gel network. These systems enhance drug penetration through the skin, support higher drug loading, and minimize irritation. Their non-greasy texture and smooth consistency contribute to improved patient acceptability. Additionally, nano-emulgels can improve pharmacokinetic behavior by enhancing drug bioavailability and reducing unwanted side effects. Structurally, they consist of two main components: the nano-emulsion phase (which may be oil-in-water or water-in-oil) and the gel base formed by swelling polymers. Common formulation components include oils, surfactants, co-surfactants, and gelling agents, all of which play specific roles in ensuring stability and performance [36-40].

Preparation of Gel Base

The preparation of gelling media requires dissolving gelling agents in an aqueous solution until full swelling occurs. The chosen polymer is dispersed in pure water while being continuously stirred using mechanical methods under controlled conditions for a specific duration and at a constant rate. Once complete swelling is achieved, the gel base is adjusted to the desired pH for effective delivery to the topical system. Commonly used gelling agents: Carbopol 934, Carbopol 940, and hydroxypropyl methylcellulose (HPMC) are commonly used as gelling agents in nanoemulgel formulations. They enhance the formulation's thickness and may interact with surfactants to adjust its viscosity. These agents are incorporated into nanoemulsions to transform their physical state from liquid to gel, addressing issues such as low spreadability, low viscosity, and poor skin retention associated with nanoemulsions [41-44].

Incorporation of Nanoemulsion into Gel Base

The appropriate gelling agent is dissolved in distilled water with continuous stirring to prepare the gel base. The pH of the prepared gel is adjusted, then the nanoemulsion system is incorporated slowly into the prepared gel at a particular ratio with continuous stirring to get the nanoemulgel preparation. The prepared nanoemulsion is gradually incorporated into a previously hydrated gel base with continuous stirring to form a uniform nanoemulgel [45].

Fig 3: Topical Nanogel Application on Skin

Oil Phase Selection

Choosing an appropriate oil phase is a crucial step in designing nano-emulsion and nano-emulgel formulations. The properties of the oil significantly influence the performance, stability, and effectiveness of the final product. Key factors considered during selection include viscosity, permeability, chemical stability, polarity, and overall compatibility with the intended application [46].

In pharmaceutical and cosmetic systems, the oil phase may consist of either natural or synthetic lipids. In some cases, the oil itself can act as an active therapeutic component. The hydrophobic nature of the selected oil plays an essential role in enhancing the solubility of lipophilic drugs and contributes to the overall stability of the nano-emulsion system [47].

Examples of Natural Oils

Oleic Acid

Oleic acid is a widely used omega-9 fatty acid known for its biocompatibility and biodegradability. It possesses excellent solubilizing capacity and enhances drug permeation through the skin. Additionally, it exhibits antioxidant properties that may help protect cells from damage. Due to these characteristics, oleic acid is frequently used as a penetration enhancer in topical formulations containing drugs such as piroxicam and ketoprofen [48].

EmuOil

Emu oil is rich in unsaturated fatty acids, particularly oleic acid, which contributes to its ability to improve skin penetration. It exhibits anti-inflammatory, analgesic, antipruritic, and antioxidant effects. Moreover, it acts as an effective skin moisturizer, making it suitable for topical nano-emulgel formulations [49].

Teatree Oil

Tea tree oil is known for its strong antimicrobial activity, including antifungal and antibacterial effects. It is commonly used in formulations containing antifungal drugs such as itraconazole. It may also enhance therapeutic outcomes through synergistic effects. However, its potential to cause allergic reactions can limit its application in transdermal systems [50].

Eugenol

Eugenol is a phenolic compound with multiple pharmacological properties, including analgesic, anti-inflammatory, antibacterial, and local anesthetic effects. It can enhance the antimicrobial activity of certain drugs and is often used in combination formulations targeting bacterial infections [51].

In addition to these, other vegetable oils are sometimes considered, although their use may be limited due to lower drug solubility and weaker emulsification properties. Modified lipids such as medium-chain triglycerides, monoglycerides, and diglycerides are also commonly utilized due to their improved functional characteristics [52].

Surfactants and Co-surfactants

Surfactants play a fundamental role in the formation and stabilization of nano-emulsions. Their primary function is to reduce the interfacial tension between immiscible phases such as oil and water, enabling

the formation of stable, fine droplets. By preventing droplet aggregation and coalescence, surfactants help maintain the integrity of the nano-emulsion system [53].

In addition to improving stability, surfactants contribute to enhanced drug solubilization, faster absorption, and increased formulation efficiency. The selection of a suitable surfactant depends on factors such as safety, compatibility, and its ability to produce the desired type of emulsion [54].

Classification Based on HLB Value [55-58]

Surfactants are often selected based on their Hydrophilic-Lipophilic Balance (HLB) value:

- Lower HLB values favor water-in-oil (W/O) systems
- Higher HLB values favor oil-in-water (O/W) systems

Classification Based on Ionic Nature [59]

Based on their charge, surfactants are categorized as:

- **Cationic surfactants** – contain positively charged groups
- **Anionic surfactants** – contain negatively charged groups, but are generally less preferred due to higher toxicity
- **Nonionic surfactants** – widely used due to their safety, stability, and compatibility across a wide pH range
- **Zwitterionic surfactants** – contain both positive and negative charges

Among these, nonionic surfactants are most commonly used in nano-emulgel systems because they are less irritating, more stable, and biocompatible.

Biosurfactants

Natural surfactants, also known as biosurfactants, are gaining increasing attention. These are derived from biological sources such as microorganisms, including bacteria and fungi. Biosurfactants are biodegradable, less toxic, and environmentally friendly [60].

Like synthetic surfactants, they possess both hydrophilic and hydrophobic regions, allowing them to effectively reduce surface tension and stabilize emulsions. Due to their safety profile and functional efficiency, biosurfactants are considered promising alternatives in modern formulation development.

Preparation of Nano-emulgel

Nano-emulgel formulations are typically developed through a systematic process that depends on the sequence of combining the oil and aqueous phases. The method involves preparing individual phases separately and then integrating them under controlled conditions to achieve a stable and uniform system.

Initially, the active pharmaceutical ingredient (API) is incorporated into the oil phase (Phase I), where it is solubilized or uniformly dispersed. In parallel, the gel base is prepared as the aqueous phase (Phase II) by dissolving suitable gelling agents in water or a hydroalcoholic medium. These gelling agents hydrate and swell to form a viscous gel structure [61.

Once both phases are ready, the oil phase is gradually introduced into the aqueous gel phase with continuous stirring. This step is followed by high-speed homogenization to reduce droplet size and ensure uniform distribution of the oil droplets within the gel matrix. The result is a smooth and homogeneous nano-emulgel system [34].

The overall preparation process can be broadly divided into two main stages. The first stage involves the formulation of a stable nano-emulsion, where fine droplets are formed using appropriate surfactants and co-surfactants. The second stage includes the incorporation of this nano-emulsion into the preformed gel base, resulting in the final nano-emulgel with improved viscosity, stability, and application properties [35].

Characterization of Nano-emulgel

Ensuring the quality, uniformity, and stability of pharmaceutical formulations is essential for achieving the desired therapeutic outcomes. Nano-emulgels, being advanced topical delivery systems, require both conventional and specialized evaluation methods. Standard quality control tests include parameters such as pH, drug content uniformity, microbial limits, sterility, and water content. In addition to these, nano-emulgels require specific characterization techniques due to the presence of nanosized droplets within the gel matrix [62].

Zeta Potential

Zeta potential is an important parameter used to assess the surface charge of dispersed droplets and predict the stability of nano-emulgel systems. It reflects the degree of electrostatic repulsion between particles. A higher magnitude of zeta potential (either positive or negative) indicates stronger repulsive forces, which helps prevent aggregation and improves formulation stability.

Surfactants play a key role in maintaining an appropriate zeta potential by stabilizing the interface between phases. This parameter is commonly measured using instruments such as a zeta sizer or particle size analyzer based on electrophoretic mobility [37].

DROPLET SIZE AND POLYDISPERSITY INDEX *(PDI)*

Droplet size is a critical factor that influences drug release, penetration, and overall stability of nano-emulgels. It represents the average diameter of dispersed globules within the formulation. Smaller droplet sizes generally lead to enhanced surface area and improved drug delivery performance. The Polydispersity Index (PDI) indicates the uniformity of droplet size distribution. It is calculated as the ratio of the standard deviation to the mean droplet size. A lower PDI value signifies a more uniform system, whereas higher values indicate broader size distribution and potential instability. Both droplet size and PDI are typically measured using dynamic light scattering (DLS) techniques with particle size analyzers [38, 46].

Rheological Properties

Rheology deals with the flow behavior and deformation characteristics of the formulation. Nano-emulgels exhibit viscoelastic behavior, meaning they possess both liquid-like and solid-like properties. These characteristics are influenced by the concentration and interaction of oils, surfactants, and gelling agents. The viscosity and flow behavior directly affect drug release, spreadability, and stability. A suitable rheological profile ensures ease of application and formation of a uniform film over the skin. Instruments such as rotational viscometers are commonly used to evaluate these properties. Spreadability is an important parameter for topical formulations, as it determines how easily the product can be applied to the skin. It is primarily influenced by the viscosity of the nano-emulgel. The parallel-plate method is widely used to measure spreadability [59, 12, 45]. In this method, a fixed amount of formulation is placed between two glass slides. A known weight is applied to allow the upper slide to move over the lower one. The time taken for the upper slide to separate is recorded.

Spreadability is calculated using the following formula:

S=M×LTS = \frac{M \times L}{T}S=TM×L

Where:

S = Spreadability

M = Weight applied to the upper slide

L = Length of the slide

T = Time taken for the slides to separate

A shorter separation time indicates better spreadability.

CONCLUSION

Nano-emulgel represents an improved topical drug delivery system compared to conventional nano-emulsions, mainly due to its higher viscosity, better stability, and enhanced skin retention. The combination of nano-sized droplets with a gel matrix allows improved permeation of lipophilic drugs by increasing contact time and maintaining skin hydration. The performance of a nano-emulgel largely depends on the proper selection and balance of its components, including oil, surfactant, co-surfactant, and gelling agents. Careful formulation is essential to ensure stability and effectiveness. Overall, nano-emulgel offers superior drug delivery, better pharmacokinetic behavior, and enhanced therapeutic outcomes, making it a promising system for topical applications.

REFERENCES

1. Tadros T, Izquierdo P, Esquena J, Solans C. (2004): Formation and stability of nano-emulsions. Adv Colloid Interface Sci. ;108–109:303–18.
2. Gupta A, Eral HB, Hatton TA, Doyle PS. (2016): Nanoemulsions: formation, properties and applications. Soft Matter. ;12(11):2826–41.
3. McClements DJ. (2012): Nanoemulsions versus microemulsions: terminology, differences, and similarities. Soft Matter.; 8:1719–29.
4. Shakeel F, Ramadan W. (2010): Transdermal delivery of anticancer drug via nanoemulsion. Saudi Pharm J. ;18(4):203–7.
5. Lawrence MJ, Rees GD. (2012): Microemulsion-based media as novel drug delivery systems. Adv Drug Deliv Rev.; 64:175–93.
6. Ghosh V, Saranya S, Mukherjee A, Chandrasekaran N. (2013): Cinnamon oil nanoemulsion formulation by ultrasonication. Ultrason Sonochem.;20(1):367–73.
7. Kotta S, Khan AW, Pramod K, Ansari SH, Sharma RK, Ali J. (2013): Exploring scientifically validated plant extracts in anti-aging cosmetics. Phytother Res. ;27(12):1749–59.
8. Date AA, Desai N, Dixit R, Nagarsenker M. (2010): Self-nanoemulsifying drug delivery systems. Drug Dev Ind Pharm. ;36(7):751–64.
9. Solans C, Izquierdo P, Nolla J, Azemar N, Garcia-Celma MJ. (2005): Nano-emulsions. Curr Opin Colloid Interface Sci. ;10(3–4):102–10.

10. Sharma N, Bansal M, Visht S, Sharma PK, Kulkarni GT. (2010): Nanoemulsion: a new concept of delivery system. Chron Young Sci. ;1(2):2–6.
11. Kumar R, Sinha VR. (2013): Preparation and optimization of nanoemulgel. Int J Pharm Sci Res. ;4(7):2431–40.
12. Khurana S, Jain NK, Bedi PMS. (2015): Nanoemulsion based gel for transdermal delivery. Drug Dev Ind Pharm. ;41(7):1032–40.
13. Moghimipour E, Salimi A, Eftekhari S. (2016): Nanoemulgel formulation for topical delivery. Adv Pharm Bull.;6(3):391–8.
14. Gupta S, Moulik SP. (2008): Biocompatible microemulsions and nanoemulsions. J Pharm Sci.;97(1):22–45.
15. Kreilgaard M. (2002): Influence of microemulsions on cutaneous drug delivery. Adv Drug Deliv Rev.;54: S77–98.
16. Eccleston GM. (2007): Microemulsions. In: Swarbrick J, editor. Encyclopedia of Pharmaceutical Technology. p. 3552–69.
17. Azeem A, Rizwan M, Ahmad FJ, Iqbal Z, Khar RK, Aqil M, et al. (2009): Nanoemulsion components screening. Drug Dev Ind Pharm.;35(4):475–82.
18. Patel MR, Patel RB, Parikh JR, Solanki AB, Patel BG. (2009): Investigating effect of microemulsion. Drug Deliv. ;16(5):274–80.
19. Subramanian N, Ghosal SK, Moulik SP. (2005): Enhanced bioavailability of drugs using nanoemulsions. J Pharm Sci. ;94(6):1307–17.
20. Karasulu HY. (2008): Microemulsions as novel drug carriers. Expert Opin Drug Deliv. ;5(1):119–35.
21. Peltola S, Saarinen-Savolainen P, Kiesvaara J, Suhonen TM, Urtti A. (2003): Microemulsions for topical delivery. Int J Pharm.;254(2):99–107.
22. Baroli B. (2010): Penetration of nanoparticles and nanomaterials in skin. J Pharm Sci. ;99(1):21–50.
23. Benson HA. (2005): Transdermal drug delivery: penetration enhancement techniques. Curr Drug Deliv. ;2(1):23–33.
24. Prausnitz MR, Langer R. (2008): Transdermal drug delivery. Nat Biotechnol.;26(11):1261–8.
25. Cevc G. (2004): Lipid vesicles and other colloids as drug carriers. Adv Drug Deliv Rev. ;56(5):675–711.
26. Barry BW. (2001): Novel mechanisms and devices to enable successful transdermal drug delivery. Eur J Pharm Sci.;14(2):101–14.
27. Jain S, Sapre R, Tiwary AK, Jain NK. (2005): Proultraflexible lipid vesicles. J Control Release.;106(3):296–307.
28. Shafiq S, Shakeel F, Talegaonkar S, Ahmad FJ, Khar RK, Ali M. (2007): Development of topical nanoemulsion gel. AAPS PharmSciTech.;8(2):E28.
29. Kumar L, Verma S, Singh R, Prasad DN. (2010): Nanoemulsion: a promising approach. Int J Drug Dev Res. ;2(1):98–110.
30. Singh Y, Meher JG, Raval K, Khan FA, Chaurasia M, Jain NK, et al. (2017): Nanoemulsion: concepts and applications. J Control Release.; 252:28–49.
31. Kaur IP, Garg A, Singla AK, Aggarwal D. (2004): Vesicular systems in ocular delivery. Int J Pharm. ;269(1):1–14.
32. Sahu PK, Giri DD, Singh R, Pandey P, Gupta S, Shrivastava AK, et al. (2013): Therapeutic and medicinal uses of aloe vera. Pharmacogn Rev.;7(14):195–200.
33. Kakkar S, Kaur IP. (2011): Spanlastics—vesicular carriers for enhanced delivery. Int J Pharm.;413(1–2):202–10.
34. Singh RP, Sharma G, Sonali, Kumar G, Koch B, Muthu MS. (2017): Emerging role of nanotechnology. Drug Discov Today. ;22(3):609–18.
35. Kumar S, Dilbaghi N, Saharan R, Bhanjana G. (2012): Nanotechnology as emerging tool. Int J Pharm Sci Nanotechnol. ;5(1):1843–9.
36. Allen TM, Cullis PR. (2004): Liposomal drug delivery systems. Science. ;303(5665):1818–22.
37. Torchilin VP. (2014): Multifunctional nanocarriers. Nat Rev Drug Discov. ;13(11):813–27.
38. Jain KK. (2005): Nanotechnology in clinical laboratory diagnostics. Clin Chim Acta. ;358(1–2):37–54.
39. Muller RH, Radtke M, Wissing SA. (2002): Nanostructured lipid matrices. Adv Drug Deliv Rev. ;54:S131–55.
40. Wissing SA, Muller RH. (2003): Cosmetic applications for lipid nanoparticles. Adv Drug Deliv Rev. ;56(9):1257–72.
41. Pardeike J, Hommoss A, Muller RH. (2009): Lipid nanoparticles. Int J Pharm. ;366(1–2):170–84.
42. Souto EB, Muller RH. (2008): Cosmetic features and applications of lipid nanoparticles. Int J Cosmet Sci. ;30(3):157–65.
43. Mehnert W, Mader K. (2001): Solid lipid nanoparticles. Adv Drug Deliv Rev. ;47(2–3):165–96.
44. Mishra V, Bansal KK, Verma A, Yadav N, Thakur S, Sudhakar K, et al. (2018): Solid lipid nanoparticles. Nanomaterials.;8(11):1–24.
45. Ajazuddin, Saraf S. (2010): Applications of novel drug delivery system. J Pharm Bioallied Sci. ;2(3):238–43.
46. Patel HM, Patel BB, Shah CN. (2011): Nanosuspension. Int J Pharm Sci Rev Res.;5(3):30–7.
47. Desai PR, Shah PP, Hayden P, Singh M. (2010): Investigation of nanoparticle penetration. Pharm Res. ;27(1):58–67.
48. Bouwstra JA, Honeywell-Nguyen PL. (2002): Skin structure and mode of action. Adv Drug Deliv Rev. ;54:S41–55.
49. Walters KA. (2002): Dermatological and Transdermal Formulations. New York: Marcel Dekker.
50. Schaefer H, Redelmeier TE. (1966): Skin Barrier. Basel: Karger.
51. Hadgraft J. (2001): Skin, the final frontier. Int J Pharm. ;224(1–2):1–18.
52. Touitou E, Godin B. (2007): Enhancement of skin drug delivery. J Control Release. ;120(1–2):1–6.
53. Honeywell-Nguyen PL, Bouwstra JA. (2005): Vesicles as drug delivery systems. Drug Discov Today. ;10(17):1235–43.

54. El Maghraby GM. (2008): Transdermal delivery of drugs. Curr Drug Deliv. ;5(4):329–38.
55. Rhee YS, Choi JG, Park ES, Chi SC. (2001): Transdermal delivery of ketoprofen. Int J Pharm. ;228(1–2):161–70.
56. Chen H, Chang X, Weng T, Zhao X, Gao Z, Yang Y, et al. (2004): Nanoemulsion systems. Int J Pharm. ;286(1–2):15–23.
57. Shakeel F, Ramadan W. (2010): Transdermal delivery via nanoemulsion. Saudi Pharm J. ;18(4):203–7.
58. Kumar R, Philip A. (2007): Modified transdermal technologies. Drug Dev Ind Pharm. ;33(10):1077–88.
59. Williams AC, Barry BW. (2012): Penetration enhancers. Adv Drug Deliv Rev.; 64:128–37.
60. Jain S, Tiwary AK, Sapre R, Jain NK. (2007): Formulation and evaluation of ethosomes. Indian J Pharm Sci. ;69(4):533–7.
61. Gupta R, Badhe Y, Rai B, Mitra AK. (2011): Formulation and evaluation of nanoemulsion gel. J Drug Deliv Sci Technol. ;21(6):529–34.
62. Panwar AS, Upadhyay N, Bairagi M, Gujar S, Darwhekar GN, Jain DK. (2011) Emulgel: review. Asian J Pharm Life Sci. ;1(3):333–43.