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Review article

Nanoemulgel technology for cosmeceutical advancements: a synergy of therapy and beauty

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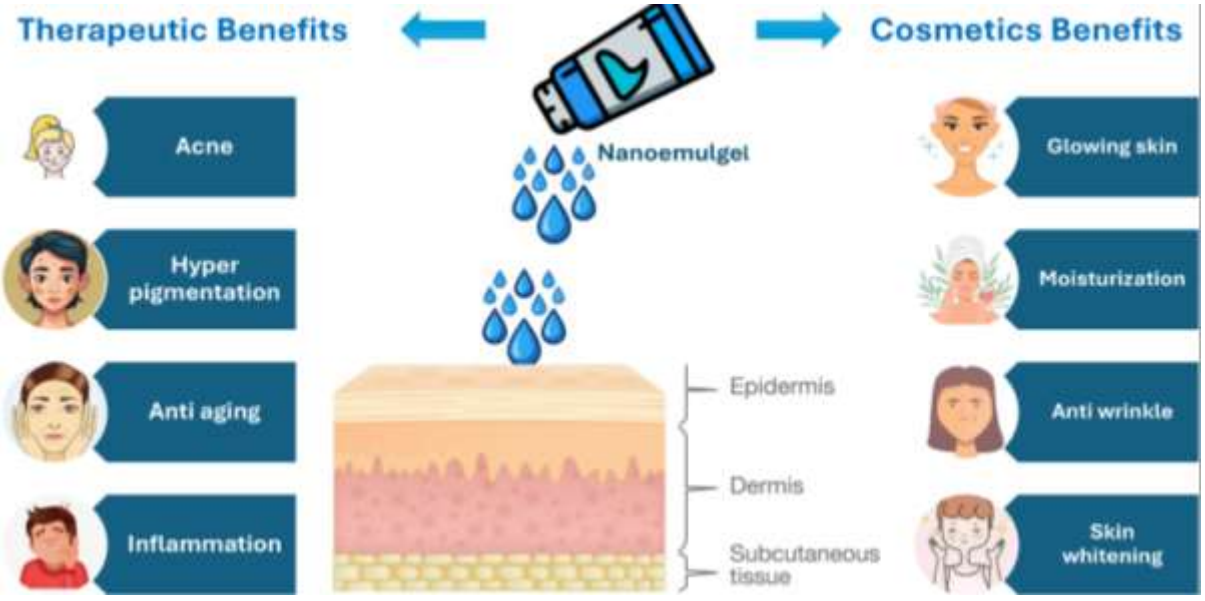
ABSTRACT

Nanoemulgel is a hybrid formulation composed of nanoemulsion and a gelling agent. The nanoemulsion incorporate the benefit of natural oil and the therapeutic effect of active pharmaceutical ingredient. The presence of a gelling agent enhances the contact time with skin layer. It offers a new way to enhance both therapeutic effectiveness and aesthetic performance. Nanoemulgel, apart from increase drug retention it also enhances solubility, and skin penetration, with gel like consistency. It is topically applied for various therapeutic purpose in various skin diseases such as psoriasis, candidiasis etc. Now a days it emerged as a potential cosmeceutical product for anti-ageing, pigmentation, acne management, UV protection, and nourishment. Preference to natural bioactive in nanoemulgel formulations makes it environmentally friendly and sustainable formulations. In recent years, the formulation development with advanced evaluation methods has reported precise therapeutic accuracy with enhanced safety profiles and performance of the nanoemugel formulations. Beside these advantages, the long-term stability, large-scale manufacture, and regulatory approval are still challenging. The invention of multifunctional cosmeceutical preparations that smoothly combine treatment and cosmetic improvement has advanced significantly through the advent of nanoemulgel technology.



Keywords: Nanotechnology, Nanoemulgel, Cosmeceuticals, Skin delivery, Therapeutic efficacy, Aesthetic enhancement.

INTRODUCTION

The worldwide cosmetics market is expected to generate $676.19 billion in revenue, showing its rapid growth by the year 2025. It is anticipated that the cosmetic industry will bring in $179 billion, accounting for a significant 42% of the market. The average American spends $210.8 on cosmetics and skincare goods, making up 42% of the market. Personalised shopping experiences are becoming increasingly popular in the business, and 77% of customers are willing to pay more for them. By the year 2025, the beauty business is predicted to reach or surpass $800 billion at a compound annual growth rate of 5% to 8% [1]. Cosmetics are any compounds that are applied topically to the body to improve oral hygiene, perfume, change one's look, or lessen body odour. According to the United States, Federal Food, Drug and Cosmetic Act of 1938, a cosmetic is any substance intended to enhance or modify one's physical appearance. Cosmetics are usually mixtures of chemicals, mostly derived from synthetic or natural sources. By 2026, the global cosmetics market is supposed to grow significantly. Skin care, body hair removal, deodorants, foundation, perfumes, sunscreen shaving cream, sunscreen, fragrances, hair and scalp products are examples of cosmetics [2]. Cosmetics can be defined as articles that have pharmaceutical therapeutic effects, but not biological ones, and are referred to as cosmeceuticals. It highlights skincare products with active substances that are meant for both nourishing and enhancing the appearance of the skin. Topical medical administration is defined as localised drug delivery through many topical routes, including rectal, oral, nasal, ocular, vaginal, and cutaneous. Due to its accessibility and ease of access, the skin is the primary site for topical medication administration [3]. A topical administration method is more beneficial as it avoids first-pass metabolism. The dosage form which is used topically to the skin, and other ways to deliver the drug to the skin, are considered as topical drug delivery system. The first-pass metabolism can be negotiated by using the topical drug administration method. The risk and inconvenience of the intravenous route therapy are also lessened [4]. Nanotechnology offers different creative solutions to augment the value of cosmetic products through the targeted delivery of content that demonstrates scientific innovation in research and development. Cosmetics employed a variety of nanosystems like microemulsion, liposomes, nanoform lipid carriers, nanoemulsion, nanosuspension, nanoemulgel and nanospheres [5]. Nanosystems displayed various novel cosmetic features, like controlled content release, site-specific targeting, more stability and improved skin penetration of loaded compounds. Hence, the cosmeceuticals are thought to be the fastest-growing segment of the personal care sector, which has progressed significantly over time. In the last few years, cosmetic science has expanded the scope of its application in various disciplines. In cosmetics, nanosystems can help to treat a variety of ailments, including wrinkles, photoaging, dandruff, hair damage and hyperpigmentation [6]. This review highlights the various nanosystems, especially nanoemulgel, used as cosmeceuticals for commercially available formulations and the targeted delivery of loaded compounds. Additionally, this review paper has described several types of formulations and the development of different nanoemulgels in cosmetics.

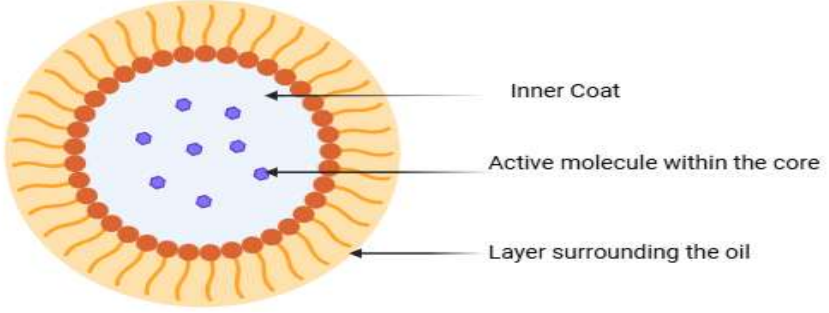
Nanoemulgel technology

The nanoemulgel technology is a contemporary cosmetic innovation that improves in enhancing the stability, delivery and therapeutic efficacy of several skincare products. Nanoemulgel is a recently developed hybrid cosmetic delivery system [7]. For the development of droplets of nanoemulsions having a size between 20 nm to 200 nm are added to the matrix of hydrogels. The nanoemulsion shown in Figure 1, that will be incorporated into the gel matrix for the development of Nanoemulgel [8]. It merges the penetration-enhancing properties of nanoemulsion with the ease of use of gels. The different types of components of nanoemulgel shows the functions in cosmetics, shown in the table.

Table 1: Components of a nanoemulgel with their specific functions

Component	Examples	Function	Reference
Active Ingredients	Vitamin, Antibiotic, Antiaging, antioxidant	Targeted cosmetic benefits	[9]
Oil Phase	Almond oil, tea tree oil, jojoba oil	Solubilise lipophilic cosmetic actives, enhance skin softness	[10]
Aqueous Phase	Purified Water	Act as a dispersion medium, hydrates skin	[11]
Surfactant	Tween 20,60,80, Span 40.60.80	Stabilises the nanodroplets by reducing interfacial tension	[12]
Co Surfactant	PEG 400, Propylene glycol	Improves transparency and stabilises droplets	[13]
Gelling Agent	Carbopol 940, HPMC	Provides Smooth texturing, spreadability, and viscosity	[14]

Figure 1: Nanoemulsion (Introduced to the matrix of gel to form nanoemulgel)

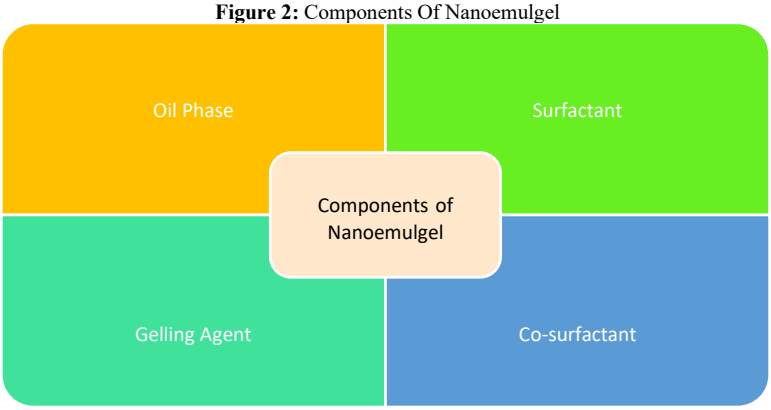


Nanoemulgel offers various number of benefits for cosmetic product formulations. The most vital advantages are their thermodynamic stability, which effectively lessens the common problems like coalescence and creaming, maintaining the product's integrity and efficacy over time. Such a type of stability is very essential for the integrity of nanoemulgel, a cosmetic composition that especially contains delicate active compounds [15]. The nanoemulgel have small size, which helps in facilitating the permeation of active ingredients topically, additionally enhancing the pharmacodynamic response at the specific site, and it improves the cosmetic product's effectiveness. The components like peptides, antioxidants and multi-vitamins are easily delivered and show desired effects as they are absorbed efficiently [16]. Moreover, the development and adaptability of the nanoemulgel help to encapsulate both hydrophilic and lipophilic molecules, making the formulation flexible, which promotes a broad spectrum of active ingredients. This flexibility facilitates the multipurpose products that are suited to a variety of consumer desires and broadens the formulation possibilities [17]. Furthermore, nanoemulgel also makes aesthetic contributions by developing transparent or translucent formulations. Consumers are more inclined to be drawn to these aesthetically pleasing items because they usually associate the clarity with efficacy and purity. Potent chemical compounds can easily be delivered via the nanoemulgel formulation. Furthermore, the environmentally friendly compounds can be used for the development of nanoemulgel. The nanoemulgel formulation has significance due to its several characteristics, which make the products long-lasting, like anti- ageing cream and moisturisers [18]. Significantly, the nanoemulgel can be formulated by using non-toxic substances and environmentally friendly materials, making them safe for a wide range of consumers and suitable for sensitive skin applications. The combined effect of strength, increased absorption, visual appeal, and controlled release and safety highlights the important role of nanoemulgel in the development of modern cosmetic products' sophistication and efficacy [19].

Formulation design for cosmetic applications

Nanoemulsion or emulsion composed of o/w or w/o type nanodroplets, and the gelling agents are the two separate systems that are used to formulate the nanoemulgel. There will be either aqueous phase or oily phase in both types of emulsion. The gel base consists of the polymers which may swelled as the liquid absorbed[20]. The components which are used for the formulation of nanoemulgel are shown in Figure 2.

Figure 2: Components Of Nanoemulgel



The oil phase, which is also known as the lipophilic phase, is a crucial drug carrier which solubilises compounds with a lipophilic nature and increases their absorption across the lipid layers. The formulated nanoemulgel can penetrate the cell walls, which allows the effective delivery of potent lipophilic medications. Various modified vegetable oils, fats like olive, palm and corn oils, as well as sesame, soybean, peanut oils, beeswax, hydrogenated soybean, Captex 355, Myritol 318, and IPM are examples of acceptable oil phases [21]. To facilitate the component dispersion, surfactants play a vital role in lessening the interfacial tension, and they possess strong solubilization capacity for hydrophobic components. For the development of nanoemulsion, the selection of surfactant is essential, having a high HLB (> 10) surfactants like polysorbate 80 forming oil/water (o/w) nanoemulsions, while lower HLB (< 10) surfactants, such as sorbitan monoesters, create water/oil (w/o) nanoemulsions. Typically, non-ionic surfactants like polysorbate 80, lecithins and poloxamers are preferred over ionic surfactants due to potential toxicological risks. Co-surfactants are required in the development of a formulation if the surfactant does not sufficiently reduce the interfacial tension. The use of such co surfactant helps in enhancing the fluidity at the interfacial surface by helping in the penetration of the surfactant monolayer, aiding in the prevention of the formation of a rigid film [22]. In the development of nanoemulgel from the nanoemulsion droplets, there is a requirement for gelling agents to stabilise a cohesive three-dimensional structural network for the topical application, stabilising formulation and optimising the delivery of the drug at a specific site. The characteristics include consistency, spreadability, rheological properties, bio-adhesion pharmacokinetics, and extrudability, are

affected by gelling agents. Natural gelling agents, including bio-polysaccharides, provide excellent biocompatibility and biodegradability but are subject to microbial degradation. Semisynthetic agents, like cellulose derivatives, are stable and offer good biocompatibility, while synthetic agents, such as carbomers and poloxamers, are FDA-approved and provide diverse rheological properties [23].

Method of preparation of nanoemulgel

Preparation of pseudoternary phase diagram

Phase diagrams will be created by mixing oil, water, and co-surfactant/surfactant mixtures at fixed weight ratios. This will be obtained by weighing ingredients, titrating with water, and stirring at room temperature. The visual appearance of the formulation confirms the monophasic/biphasic system. If there is phase separation or any sign of turbidity seen, then the sample will be considered as biphasic [24].

Before the preparation of nanoemulgel, first, there will be the formulation of nanoemulsion, which takes place using several types of techniques. These techniques can be high-energy and low-energy techniques for the preparation of nanoemulsions. High-energy techniques like microfluidization, high-pressure homogenization, and ultrasonication. These are all techniques employing mechanical energy to formulate the nanosized droplets. In the High-pressure homogenization techniques, there will be generation of tiny droplets under extreme turbulence and shear at high pressure, but it can raise the temperature of the emulsion[25]. For the effective size reduction, the techniques named Microfluidization utilise very strong turbulence and hydraulic shear at high pressure, while in the other techniques, like ultrasonication, it modifies the ultrasonic energy to achieve the desired particle size, primarily suited for all types of small batch formulation of emulsion. Low-energy methods depend on chemical energy for the process of emulsification, with techniques of phase inversion emulsification, which changes the self-emulsification and surfactant curvature, forming the nanoemulsion droplets without altering surfactant properties. This review also discusses the use of various gelling agents to create semi-solid nanoemulgels, which involves mixing drug-loaded nanoemulsions with gelling agents while stabilising pH with triethanolamine, allowing for a homogeneous gel dispersion over 24 hours [26].

Characterisation of Nanoemulgel [27]

Determination of encapsulation efficiency

Zeta potential

Determination of particle size

Polydispersity index (PDI)

Viscosity

Refractive index

Dilutability test

Conductance measurement

Osmolarity & pH measurement

Interfacial tension

Fourier transform infrared (FTIR) spectroscopy analysis.

Atomic Force Microscope (AFM)

In vitro skin permeation studies

In vitro drug release studies

In vivo study

Stability study

Mechanism of skin penetration

Through the process of diffusion, drugs permeate the skin's epidermal layer and its appendages. Three routes—the transcellular route, the paracellular lipid route, and the transappendgeal route can permit drugs to enter the body[26]. The transcellular route involves drug molecules crossing the skin through phospholipid membranes and dead keratinocytes' stratum corneum, allowing small and moderately lipophilic molecules to enter the cytoplasmic domain [28]. This route is limited to highly lipophilic and large molecules. The paracellular route allows hydrophilic molecules to permeate through lipid membranes, allowing them to remain in the lipid moiety and stay around the keratin. The transappendgeal route, also known as the shunt route, transports large and water-soluble drug molecules, covering only 0.1% of the skin surface. This route is crucial for ions and large polar molecules that hardly permeate through the stratum corneum [29].

Cosmeceutical applications of nanoemulgels

Due to the unique combination of nano-sized droplets with a gel-based matrix of nanoemulgels formed by highly advanced cosmetic delivery systems, the stability, penetration, and bioavailability of different cosmetic active compounds are enhanced. The smaller droplet-like size enables the deeper penetration of active constituents into the skin, along with the gel-like structures, which improve the spreadability, controlled release of components, aesthetic appeal and make them superior to conventional lotions and creams [30]. These factors allow the nanoemulgels to perform effectively when applied across the multi cosmeceutical domains, like skin whitening, anti-acne, anti-ageing, sun protection, hydration, anti-inflammatory, hair and scalp applications and anti-pollution [31]. The given figure shows that the “Cosmeceutical Applications of Nanoemulgels” helps to represent the wide and versatile application of nanoemulgel.

Similarly, the given table shows the major cosmeceutical categories, with active ingredients and mechanism of action, with the specific advantages of the nanoemulgel-based delivery system. The table describes the improved stability, product performance, boost dermal penetration and enhance overall consumer acceptability across diverse skin care and haircare formulations.

Figure 3: Cosmeceutical applications of Nanoemulgels

Table 2: Cosmeceutical Nanoemulgel with their mode of action

Cosmeceutical Category	Active Components	Mode of Action	Outcomes	References
Anti cellulite	Caffeine, Carnitine	Increased delivery to subcutaneous tissues.	Improved skin tightening	[32], [33]
Skin whitening	Kojic acid, Niacinamide	Enhanced solubility through the stratum corneum	Faster depigmentation, Higher penetration	[34], [35]
Sunscreen	Zinc oxide, titanium dioxide	Improves UV coverage	Higher SPF, invisible finish	[36]
Hair applicants	Biotin, Ketoconazole	Improved follicular penetration	Better scalp, enhanced follicle stimulation	[37], [38]
Anti inflammatory	Curcumin, Aloe vera	Increases the stability of polyphenols	Improved soothing effect, better healing	[9], [39]
Moisturization	Hyaluronic acid, ceramides	Boosts deeper lipid delivery	Long-lasting hydration	[40], [41]
Acne management	Clindamycin, Salicylic acid	Enhance follicular targeting	Reduced dryness, improved tolerability	[42], [43]
Photoprotection	Avobenzone, Octocrylene	Enhances photostability	Non-greasy texture, transparent finish	[44]
Anti-aging	Retinol, Vitamin E	Protects unstable molecules	Increased collagen synthesis	[45], [46]
Anti-pollution	Vitamin C, Ferulic Acid	Increase chemical stability	Protection against oxidative stress, environmental repair	[47], [48]
Anti-oxidant	Green tea Polyphenols	Continuous antioxidant release	Retinol gels, antioxidant anti-ageing gel	[49], [50]
Anti-wrinkle	Resveratrol	Deeper dermal targeting	Reduced wrinkles, improved firmness	[51], [52]

Figure 4: The recent trends and innovations in cosmetic nanoemulgels

Safety, regulatory, and consumer perspectives

Nanoemulgel-based cosmetics have safety assessments that are essential, as the nanoscale droplets influence the skin permeation and biological interactions. However, the dermatological evaluations, like irritation, sensitisation, stability testing and photo toxicity are performed with the help of advanced analyses like particle size measurement, zeta potential and cytotoxicity studies, which ensure skin compatibility [5]. Regulatory bodies also maintain restricted oversight: the U.S. FDA needs the detailed safety documentation for the nanoemulgel formulation, the EU Cosmetics Regulatory bodies give the instructions and labelling of nano ingredients and Indian agencies like BIS and CDSCO, which emphasise the GMP compliance and risk assessment of nanoparticles [56]. From the consumer perspectives, the nanoemulgel is increasingly accepted as it has lightweight, improved penetration and enhanced performance in products like hydration, antiaging and dermal repair formulations[57]. The market trends reveal the increasing interest in scientifically backed, fast-acting skincare solutions, although the consumer trust still relies on the clear communication of safety, transparent labelling and responsible marketing to ensure confidence in nano-based cosmetic products [58].

Challenges and future outlook

Nanoemulgels, which incorporate the active components, have several advantages but still face problems and challenges mainly related to the large-scale production, cost and stability. Moving towards the industries from the lab scale requires restriction control

over the droplet size and viscosity along high-energy emulsification equipment, which makes the process expensive and technically demanding [59]. Texture changes, Ostwald ripening and phase separation are the stability issues which are critical concerns for cosmetic products, which help in maintaining the shelf life and quality of the product. Moreover, the expensive and premium surfactants, natural oils and gelling agents limit the wide use in the large-scale or industrial-level formulations. The cosmetic industry is mainly focusing on the eco-friendly nanoemulgel formulation by using natural surfactants, biodegradable polymers and solvent-free or low-energy manufacturing methods [60]. Recent research shows the eco-friendly, stimuli-responsive and multi-tasking nanoemulgel, which can deliver moisturising, anti-ageing and protective benefits in a single product. Along with the growing interest of consumers and a clearer regulatory framework, nanoemulgels become a key platform in the next generation of cosmetic nanoemulgels formulation, which provides the challenges in scale up, long-term stability and cost effectiveness are successfully addressed [61].

CONCLUSION

Nanoemulgel technology gives a flexible and effective substrate for delivering different types of active components, which is a major contribution in contemporary cosmetic research. In comparison to traditional formulations, nanoemulgels provide higher skin permeation, stability, and aesthetic appeal by fusing the high solubilization capacity of nanoemulgels with the superior spreadability and skin-adhesion of gel systems. Recent studies have gradually overcome these constraints through innovative formulation strategies and more environmentally friendly manufacturing processes, despite hurdles that involve scale-up, long-term stability, and regulatory compliance. Along with enhancing the consumer demand for effective, lightweight and scientifically backed cosmetic products, nanoemulgels are becoming the next generation of skincare and personal care products. Next-generation skincare and personal care products are expected to use nanoemulgels extensively.

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Conflict of interest

The authors declare that there are no known competing financial interests or personal relationships regarding this publication of a review paper.

REFRENCE

1. Mondello A, Salomone R, Mondello G, 2024. Exploring circular economy in the cosmetic industry: Insights from a literature review. Environmental Impact Assessment Review. 105, Pages 107443, Doi: https://doi.org/10.1016/j.eiar.2024.107443.

2. Burdock G A, 2024. Review of the standards of proof (of safety) for FDA regulated consumer products and how the generally recognized as safe criteria could be applied to cosmetics. Regulatory Toxicology and Pharmacology. 149, Pages 105603. Doi: https://doi.org/10.1016/j.yrtph.2024.105603.

3. Olivero-Verbel J, Quintero-Rincón P Caballero-Gallardo, 2024. Aromatic plants as cosmeceuticals: benefits and applications for skin health. Planta. 260(6), Pages 132. Doi: https://doi.org/10.1007/s00425-024-04550-8.

4. Hu X, He H, 2021. A review of cosmetic skin delivery. Journal of Cosmetic Dermatology. 20(7), Pages 2020-2030. Doi: https://doi.org/10.1111/jocd.14037.

5. Ferraris C, Rimicci C, Garelli, et al, 2021. Nanosystems in cosmetic products: A brief overview of functional, market, regulatory and safety concerns. Pharmaceutics. 13(9), Pages 1408. Doi: https://doi.org/10.3390/pharmaceutics13091408.

6. Kashyap N, Kumari A, Raina N, et al, 2022. Prospects of essential oil-loaded nanosystems for skincare. Phytomedicine Plus. 2(1), Pages 100198. Doi: https://doi.org/10.1016/j.phyplu.2021.100198.

7. Kumar P, Hussain Z, Chandra P, et al, 2025. Nanoemulgel: An Innovative Carrier for Drug Delivery of Poorly Water-soluble Drugs. Current Nanomedicine. 15(2), Pages 157-172. Doi: https://doi.org/10.2174/0124681873286701240320111432.

8. Donthi M R, Munnangi S R, Krishna K V, et al, 2023. Nanoemulgel: a novel nano carrier as a tool for topical drug delivery. Pharmaceutics, 15(1), Pages 164. Doi: https://doi.org/10.3390/pharmaceutics15010164.

9. Bagheri A M, Ranjbar M, Karami-Mohajeri S, et al, 2024. Curcumin nanoemulgel: Characterisation, optimisation, and evaluation of photoprotective efficacy, anti-inflammatory properties, and antibacterial activity. Journal of Cluster Science, 35(7), Pages 2253-2272. Doi: https://doi.org/10.1007/s10876-024-02651-8.

10. Yap X F, Saw S H, 2024. Plant essential oil nanoemulgel as a cosmeceutical ingredient: A review. Cosmetics, 11(4), Pages 116. Doi: https://doi.org/10.3390/cosmetics11040116.

11. Vazir A, Joshi A, Kumar K, et al, 2023. Nanoemulgel: For Promising Topical and Systemic Delivery. International Journal of Pharmaceutics and Drug Analysis. 5, Pages 8-13. Doi: https://doi.org/10.47957/ijpda.v11i4.561.

12. Wojcieszak, M, Illienko K, Różański J, et al, 2025. Evaluation of non-ionic surfactant-based emulgels as a prospective approach for skincare products. Journal of Molecular Liquids. 431, Pages 127702. Doi: https://doi.org/10.1016/j.molliq.2025.127702.

13. Younes H M, Sallam A A, Saifan L A, et al, 2025. Development and Pharmacokinetic Evaluation of Newly Formulated Letrozole Non-Aqueous Nanoemulgel Transdermal Systems for Hormone-Dependent Breast Cancer Therapy. Pharmaceutics. 17(11), Pages 1444. Doi: https://doi.org/10.3390/pharmaceutics17111444.

14. Nastiti C M R R, Dwiastuti,, 2023. Novel quercetin nanoemulgel optimization: Gelling agents' evaluation and the application of response surface methodology. International Journal of Applied Pharmaceutics. 15(1), Pages 72-78. https://doi.org/10.22159/ijap.2023v15i1.46585.

15. Ojha B, Jain V K, Gupta S, et al, 2022. Nanoemulgel: A promising novel formulation for treatment of skin ailments. Polymer Bulletin. 79(7), Pages4441-4465.Doi: https://doi.org/10.1007/s00289-021-03729-3.

16. Morteza-Semnani K, Saeedi M, Akbari J, et al, 2022. Development of a novel nanoemulgel formulation containing cumin essential oil as skin permeation enhancer. Drug delivery and translational research. 12(6), Pages 1455-1465. Doi: https://doi.org/10.1007/s13346-021-01025-1.

17. Septiyanti M, Oktami G, Sutriningsih Y, 2022, December. Formulation and stability study of fermented soybean extract nanoemulgel. Pages 2493, 1, Pages 070015. Doi: https://doi.org/10.1063/5.0109978.

18. Ain N U, Akhlaq M H, Zhu K, et al, 2025. A nanoemulgel formulation of acetylated Crataegus pinnatifida polysaccharide for the treatment of skin photoaging in mice. International Journal of Biological Macromolecules, 303, Pages 140649. Doi: https://doi.org/10.1016/j.ijbiomac.2025.140649.

19. Abu-Huwaij R, Al-Assaf, 2022. Recent exploration of nanoemulsions for drugs and cosmeceuticals delivery. Journal of cosmetic dermatology. 21(9), Pages 3729-3740. Doi: https://doi.org/10.1111/jocd.14704.

20. Nining N, Amalia A, Zahrok F, 2023. Response surface methodology for optimization of turmeric essential oil-loaded nanoemulgel. Journal of Research in Pharmacy. 27(4), Pages 1499-1512. Doi: http://dx.doi.org/10.29228/jrp.436.

21. Sari T S, Munandar T E, Chang H I, et al, 2025. Formulation and Physicochemical Evaluation of Nanoemulgel Star Anise Essential Oil (Illicium verum Hook. f.) and Butterfly Pea Extract (Clitoria ternatea L.) as Antioxidant Cosmetics. Trends in Sciences. 22(11), Pages 10166-10166. Doi: https://doi.org/10.48048/tis.2025.10166.

22. Chitkara A, Mangla B, Kumar P, et al, 2022. Design-of-experiments (DoE)-assisted fabrication of quercetin-loaded nanoemulgel and its evaluation against human skin cancer celllines. Pharmaceutics. 14(11), Pages 2517. Doi: https://doi.org/10.3390/pharmaceutics14112517.

23. Dev S K., Choudhury P K, Srivastava R, et al, 2024. Formulation and optimisation of polyherbal Nanogel for dermatological applications. Current Nanomaterials. 9(1), Pages 70-82. Doi: https://doi.org/10.2174/2405461508666230324084617.

24. Jana B K, Singha I, Puro N, et al, 2025. Pseudo-ternary phase diagram-based PEGylated nano-dispersion of linezolid to promote wound regeneration: an in vitro and in vivo evaluation. Journal of Drug Targeting. 33(6), Pages 989-1003. Doi: https://doi.org/10.1080/1061186X.2025.2461093.

25. Kayiran S D, Guven Bolgen U M, Cevikelli, et al, 2025. Chemical Characterization, Cytotoxic Activity, and Antimicrobial Potential of Nanoemulsions Based on Cymbopogon citratus Essential Oils. ACS omega. 10(30), Pages 33932-33945. Doi: https://doi.org/10.1021/acsomega.5c06077.

26. Agarwal V, 2025. Evolution and Characterization of Stabilized Nano-emulgel Loaded with Tacrolimus for Improving Topical Application. Micro and Nanosystems. (17)4, Pages 312 - 328 Doi: https://doi.org/10.2174/0118764029355351250414021711.

27. Pathak P, Alam K, Beg S, et al, 2024. Natural seed oil-loaded emulgel/nanogel in topical infectious disorders. In Nanostructured Drug Delivery Systems in Infectious Disease Treatment. Pages 377-385. Doi: https://doi.org/10.1016/B978-0-443-13337-4.00022-7.

28. Alfanura A S, Hayati F, Indrati O, 2025. Skin Models for Nanoemulgel Permeation: An Overview of Current Practices. Precision Nanomedicine. Pages 1561-1569. Doi: https://doi.org/10.33218/001c.xxxxxx.

29. Mohammadi-Samani S, Masoumzadeh P, Ghasemiyeh P et al, 2022. Oxybutynin-nanoemulgel formulation as a successful skin permeation strategy: in-vitro and ex-vivo evaluation. Frontiers in Materials. 9, Pages 848629. Doi: https://doi.org/10.3389/fmats.2022.848629.

30. Alhasso B, Ghori M U, Rout S P, et al , 2023. Development of a Nanoemulgel for the Topical Application of Mupirocin. Pharmaceutics. 15(10), Pages 2387. Doi: https://doi.org/10.3390/pharmaceutics15102387.

31. Ma Q, Zhang J, Lu B, et al, 2021. Nanoemulgel for improved topical delivery of desonide: formulation design and characterization. AAPS PharmSciTech. 22(5), Pages 163. Doi: https://doi.org/10.1208/s12249-021-02035-5.

32. Fouad S A, Badr T A, Abdelbary A, et al, 2024. New Insight for Enhanced Topical Targeting of Caffeine for Effective Cellulite Treatment: In Vitro Characterization, Permeation Studies, and Histological Evaluation in Rats. AAPS PharmSciTech. 25(7), Pages 237. Doi: https://doi.org/10.1208/s12249-024-02943-2.

33. Hameed H I, Al-Mayahy, 2024. Combined approach of nanoemulgel and microneedle pre-treatment as a topical anticellulite therapy. ADMET and DMPK. 12(6), Pages 903-923. Doi: https://doi.org/10.5599/admet.2461.

34. Ayuhastuti A, Syah ISK, Megantara S, et al, 2023. A Comprehensive Review of the Cosmetic Application of Kojic Acid Dipalmitate: Kojic Acid Derivative with Improved Properties. Doi: https://doi.org/10.20944/preprints202312.2196.v1.

35. Ayuhastuti A, Syah ISK, Megantara S, 2024. Nanotechnology-enhanced cosmetic application of kojic acid dipalmitate, a kojic acid derivate with improved properties. Cosmetics. 11(1), Pages 21. Doi: https://doi.org/10.3390/cosmetics11010021.

36. Anditha AT, Chiuman L, Ginting C N, 2024. UV-Protection Effect of Nanoemulgel Formulation from Moringa oleifera Lam. Leaf Extracts in Rattus novergicus. Jurnal Penelitian Pendidikan IPA. 10(9), Pages 6603-6611. Doi: https://doi.org/10.29303/jppipa.v10i9.8497.

37. Ain S, Ain Q, Chauhan, et al, Preparation And Evaluation Of Ketoconazole Nanogel For Topical Application.Eur. Chem. Bull. 2025. 14(Regular Issue 1), Pages 61-7 Doi: 510.53555/ecb.v14:i1.17867.

38. Giri Y, Behera A, Mohanty B, et al, 2025. Design and Development of Ketoconazole Loaded Nanoemulgel for the Improved Topical Therapy of Onychomycosis Using Chemical Penetration Enhancers. Journal of Pharmaceutical Innovation. 20(3), Pages 93. Doi: https://doi.org/10.1007/s12247-025-09999-y

39. Soliman WE, Shehata TM, Mohamed ME, et al, 2021. Enhancement of curcumin anti-inflammatory effect via formulation into myrrh oil-based nanoemulgel. Polymers. 13(4), Pages 577. Doi: https://doi.org/10.3390/polym13040577

40. Martin M, Chantemargue B, Trouillas P, 2025. Skin hydration by natural moisturizing factors, a story of H-bond networking. The Journal of Physical Chemistry B. 129(3), Pages 844-852. Doi: https://doi.org/10.1021/acs.jpcb.4c05473.

41. Mauri E, Scialla S, 2023. Nanogels based on hyaluronic acid as potential active carriers for dermatological and cosmetic applications. Cosmetics. 10(4), Pages 113. Doi: https://doi.org/10.3390/cosmetics10040113.

42. Dragicevic N, Maibach H I, 2024. Liposomes and other nanocarriers for the treatment of acne vulgaris: improved therapeutic efficacy and skin tolerability. Pharmaceutics. 16(3), Pages 309. Doi: https://doi.org/10.3390/pharmaceutics16030309.

43. Singh V, Redhu R, Verma R,et al, 2021. Anti-acne treatment using nanotechnology based on novel drug delivery system and patents on acne formulations: a review. Recent Patents on Nanotechnology. 15(4), Pages 331-350. Doi: https://doi.org/10.2174/1872210514999201209214011.

44. Mohanty S, Badhei L, Pal Abhishek, 2022. Novel cosmeceutical formulations: A better approach to photoprotection. Int. J. Appl. Pharm. 14, Pages 9-17. Doi: https://dx.doi.org/10.22159/ijap.2022v14i4.44602.

45. Ansari R, Farooq U, Ali A, et al, 2025. Anti-ageing Potential of Metformin Loaded Fennel Oil-Based Nanoemulgel: A Promising Novel Approach for Ultraviolet B-Induced Ageing. International Journal of Pharmaceutics. 676, Pages 125559. Doi: https://doi.org/10.1016/j.ijpharm.2025.125559.

46. Drais H K, Ihmedee F H, 2025. Green Synthesis of Anti-Aging Gel Mask Contains Essential Oils Based Nanoemulsions. Iraqi Journal of Industrial Research. 12(1), Pages 144-157. Doi: https://doi.org/10.53523/ijoirVol12I1ID505.

47. Raszewska-Famielec M, Flieger J, 2022. Nanoparticles for topical application in the treatment of skin dysfunctions—an overview of dermo-cosmetic and dermatological products. International Journal of Molecular Sciences. 23(24), Pages 15980. Doi: https://doi.org/10.3390/ijms232415980.

48. Yücel Ç, Karatoprak G Ş, Ilbasmis-Tamer S, 2023. Ferulic acid-loaded aspasomes: A new approach to enhance the skin permeation, anti-aging and antioxidant effects. Journal of Drug Delivery Science and Technology. 86, Pages 104748. Doi: https://doi.org/10.1016/j.jddst.2023.104748.

49. Kawee-Ai A, 2025. Advancing Gel Systems with Natural Extracts: Antioxidant, Antimicrobial Applications, and Sustainable Innovations. Gels. 11(2), Pages 125. Doi: https://doi.org/10.3390/gels11020125.

50. Sykuła A, Janiak-Włodarczyk I, Kapusta IT, 2025. Formulation and Evaluation of the Antioxidant Activity of an Emulsion Containing a Commercial Green Tea Extract. Molecules. 30(1), Pages197. Doi: https://doi.org/10.3390/molecules30010197.

51. Alyoussef A, El-Gogary RI, Ahmed RF, et al, 2021. The beneficial activity of curcumin and resveratrol loaded in nanoemulgel for healing of burn-induced wounds. Journal of Drug Delivery Science and Technology. 62, Pages 102360. Doi: https://doi.org/10.1016/j.jddst.2021.102360.

52. Mascarenhas-Melo F, Araújo AR, Rodrigues M, et al, 2023. Dermatological bioactivities of resveratrol and nanotechnology strategies to boost its efficacy—An updated review. Cosmetics. 10(3), Pages 68. Doi: https://doi.org/10.3390/cosmetics10030068.

53. Araujo S, Rodrigues M, Mascarenhas-Melo F, et al, 2022. New-generation nanotechnology for development of cosmetics using plant extracts. In Nanotechnology for the Preparation of Cosmetics Using Plant-Based Extracts. Pages 301-325. Doi: https://doi.org/10.1016/B978-0-12-822967-5.00002-3

54. Bhadouria VS, Verma S, Mishra R, et al, 2024. Beyond Creams and Gels: The Emergence of Emulgels in Pharmaceutical Science. Curr. Drug Ther. Pages 1230–1243, Doi: 10.2174/0115748855320930240920040523.

55. Singh K, Gupta JK, Shamim Muztaba M, et al, 2025. Emerging Applications and Innovations in Emulgel Technology for Enhanced Topical Drug Delivery. Drug Delivery Letters. Doi: 10.2174/0122103031384904250930153320.

56. Srivastava S, 2025. Regulatory aspects and commercialisation of nanogel-based products in pharmaceutical applications. In Nanogels. Pages 383-400. Woodhead Doi: https://doi.org/10.1016/B978-0-443-30016-5.00009-4.

57. Javaid, A., Imran, M., Latif, S., et al, 2022. Multifunctional attributes of nanostructured materials, toxicology, safety considerations, and regulations. Journal of Materials Science, 57(36), pp.17021-17051. https://doi.org/10.1007/s10853-022-07679-7

58. IC Festus-Ikhuoria, NC Obiuto, RA Adebayo, et al 2023, Nanotechnology in consumer products: A review of applications and safety considerations," World J Adv Res Rev. 21, Pages 2050–2059. Doi: https://doi.org/10.30574/wjarr.2024.21.3.0923.

59. Pan X, Zhou H, Li Z, et al, 2025. Application and safety research of nanotechnology in cosmetics: current status, challenges, and future prospects. BioNanoScience. 15(2), Pages 1-59. Doi: https://doi.org/10.1007/s12668-025-01884-9.

60. Salau A K, Shehu MS, Adisa KO, et al, 2025. Nanoemulsion drug delivery systems for dermatological disorders: a review of mechanisms, clinical applications and commercial advances. UMYU Scientifica. 4(2), Pages 175-192. Doi: https://doi.org/10.56919/usci.2542.019.

61. Ariyanta HA, Sholeha NA, Fatriasari W, 2025. Current and Future Outlook of Research on Renewable Cosmetics Derived From Biomass. Chemistry and Biodiversity. Pages 202402249. Doi: https://doi.org/10.1002/cbdv.202402249.