RESEARCH PAPER

Nanoemulgel-Based Therapies for Psoriasis: Current Advances, Global Research Trends, and Future Perspectives

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ABSTRACT

Background

Psoriasis is a persistent, immune-mediated inflammatory dermatological condition that imposes considerable clinical and psychological distress. Topical therapy continues to be a principal treatment method; however, traditional formulations frequently exhibit inadequate skin penetration and restricted therapeutic effectiveness.

Objective

This study seeks to give a thorough assessment of innovations in nanoemulgel-based drug delivery systems for psoriasis treatment, as well as to conduct a bibliometric analysis of worldwide research trends, focal points, and collaboration networks in this field.

Methods

A comprehensive literature search covering the period from 1995 to June 2025 was performed on Web of Science, Scopus, and PubMed. A bibliometric study was conducted utilizing CiteSpace, VOSviewer, R-bibliometrix, and ScimagoGraphica to evaluate publication patterns, author collaborations, keyword development, and citation networks.

Results

A substantial increase in publications post-2015 indicates accelerating research momentum. India, China, and the USA emerged as leading contributors. Nanoemulgels incorporating methotrexate, curcumin, tacrolimus, and other agents demonstrated enhanced dermal delivery, prolonged retention, and significant anti-inflammatory outcomes in preclinical models. Emerging trends include dual-drug systems, herbal combinations, and thermosensitive/bioadhesive gels.

Conclusion

Nanoemulgels offer a promising platform for targeted, sustained, and patient-compliant topical psoriasis therapy. While preclinical evidence is robust, translational hurdles such as regulatory ambiguity, long-term safety, and formulation scalability must be addressed. Future research should emphasize smart-responsive systems, AI-assisted optimization, and biomarker-driven personalization to fully harness the clinical potential of nanoemulgel-based therapeutics.

Keywords: Psoriasis, Nanoemulgel, Topical Drug Delivery, Nanocarriers, Bibliometric Analysis, Smart Systems, Personalized Therapy.

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Introduction

Psoriasis is a chronic, relapsing, immune-mediated dermatological condition that impacts between 2–5% of the worldwide populace, primarily presenting as plaque psoriasis, but also encompassing variants such as erythrodermic, guttate, pustular, and psoriatic arthritis.[1] Psoriasis is recognized not just for its skin effects but also as a systemic inflammatory disorder linked to several comorbidities, such as cardiometabolic diseases, psoriatic arthritis, and depression, hence increasing its overall disease burden. [2] The pathophysiological characteristic of psoriasis is the dysregulation of the Th17/IL-23/IL-17 immunological axis, characterized by activated dendritic cells secreting IL-23, which promotes Th17 cell development and the subsequent generation of IL-17A, IL-22, and TNF-α. These pro-inflammatory cytokines promote keratinocyte hyperproliferation and perpetuate persistent cutaneous inflammation. [3]

The intricate immunological cascade, together with genetic predispositions like HLA-C*06:02 and environmental triggers such as infections, stress, obesity, and smoking, influences the disease phenotype and its variable clinical progression. [4]

Topical treatment is fundamental in the administration of mild-to-moderate psoriasis and is essential for sustaining remission in more severe instances. In the last century, the therapeutic landscape has undergone considerable evolution: the initial documentation of coal tar in conjunction with UV radiation occurred in 1925, succeeded by the development of topical corticosteroids in 1952, emollient-based formulations in 1955, and Vitamin D analogues in 1991. [5–7] Subsequent developments encompassed tazarotene, a topical retinoid, and calcineurin inhibitors like tacrolimus, providing steroid-sparing options for delicate areas. [8–10] Notwithstanding these advancements, traditional topical formulations such as creams, ointments, and lotions are impeded by inadequate skin penetration, insufficient drug retention, and frequent dose necessities, frequently resulting in treatment non-adherence and subpar results. [11]

To address these constraints, researchers have utilized nanocarrier-based drug delivery systems that augment drug solubility, boost skin permeability, and facilitate sustained release. [12] Nanoemulgels have emerged as notably promising platforms among these advances. They integrate the exceptional solubilizing ability and nanoscale droplet dimensions (<200 nm) of nanoemulsions with the viscosity, adhesion, and controlled release characteristics of gels, resulting in greater skin penetration, extended residence duration, and better patient adherence. [13] Figure 2 This combined benefit renders nanoemulgels particularly pertinent for the administration of both traditional antipsoriatic drugs (e.g., methotrexate, corticosteroids) and innovative bioactives (e.g., herbal medicines, small-molecule inhibitors). [14]

Despite the increasing number of studies investigating nanoemulgels for psoriasis, there remains a paucity of comprehensive reviews that consolidate the technological advancements, therapeutic implications, and research trends in this field.[15] This review aims to bridge that gap by providing a systematic synthesis of the evolution, formulation strategies, and therapeutic potential of nanoemulgels in psoriasis management, supplemented by a bibliometric analysis to map global research activity and identify emerging hotspots in this domain.[16]

In addition to formulation challenges, the successful clinical translation of nanoemulgels demands attention to patient-centric design, stability, and regulatory clarity. Given that these systems straddle the line between conventional topical agents and nanomedicines, global regulatory bodies such as the FDA and EMA have yet to provide definitive frameworks for safety and quality standards. This regulatory ambiguity, combined with formulation complexity, underscores the importance of interdisciplinary collaboration in advancing nanoemulgel technologies. [17]

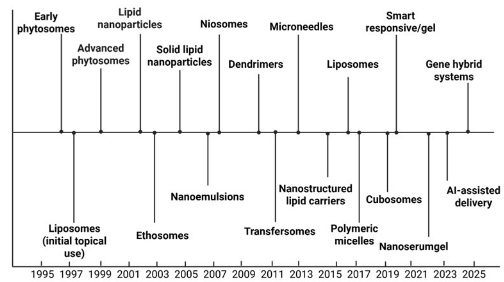

Figure 1. Timeline of novel drug delivery systems explored for the topical management of psoriasis (2000–2025). The figure highlights the chronological emergence of various advanced formulations, including hydrogels, lipid-based carriers, vesicular systems, microneedles.

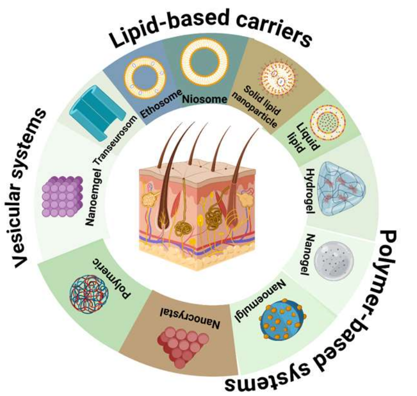

Figure 2. Schematic illustration of the anatomical structure of human skin and representative novel drug delivery systems developed for the topical treatment of psoriasis from 1995 to 2025. The figure categorizes delivery platforms into polymer-based systems, vesicular systems, and lipid-based carriers, highlighting advancements such as nanoemulgel, transferosomes, ethosomes, and Nano crystals.

Materials and Methods

Data Collection

An advanced literature search was performed in the Science Citation Index Expanded (SCI-EXPANDED) of the Web of Science Core Collection (WoSCC), as well as PubMed and Scopus, to retrieve publications related to nanoemulgels for psoriasis. The search was conducted on 30 June 2025 using the following strategy: TS = (nanoemulgel”) AND TS = (psoriasisOR topical drug delivery”). The time frame for the search was set between 1 January 1995and 30 June 2025, and the document types were restricted to original research articles and review articles published in English. Records meeting the inclusion criteria were exported in Full Record and Cited Referencesformat for subsequent analysis. (Figure 3**)**Duplicate entries and non-relevant publications (e.g., unrelated formulations or diseases) were manually screened and excluded to ensure dataset accuracy**.**

Bibliometric Analysis Tools

To visualize and analyze publication trends and research networks, we employed a combination of CiteSpace (6.2.R4), VOSviewer (1.6.19), the bibliometrix package in R (version 4.4.0), and ScimagoGraphica. CiteSpace was utilized to map collaboration networks among authors, institutions, and countries, as well as to identify co-cited references and their clustering patterns. VOSviewer facilitated the generation of keyword co-occurrence maps and thematic clustering to identify emerging research hotspots. R-bibliometrix, integrated with RStudio, was applied for statistical analyses of publication output, citation counts, h-index values, and betweenness centrality, offering deeper insights into author and institutional productivity. ScimagoGraphicawas used to visualize geographical distributions and collaborations at a global scale, providing an intuitive representation of country-level research activity. Although not the main focus, bibliometric filters were applied to assess studies discussing regulatory classification and safety evaluations of nanoemulgels. This included keywords like "FDA," "safety," and "toxicity," helping to map the translational bottlenecks

Statistical Models and Data Processing

To forecast research trends, linear regression models were constructed using publication year as the independent variable and annual publication volume and cumulative citations as dependent variables. Where necessary, logarithmic transformations were applied to stabilize data variance and improve model fit. Model performance was evaluated using R-squared (R^2) to assess explained variance and Mean Squared Error (MSE) to quantify prediction accuracy. Additionally, h-index values were calculated to evaluate the scholarly impact of authors and institutions, while betweenness centrality metrics were applied to identify nodes within collaboration networks.

Results

Analysis of Publication Trends and Citation Frequency

The bibliometric analysis revealed a steady and pronounced growth in research activity on nanoemulgels for psoriasis over the last decade. While early studies between 1995 and 2010 were sporadic and exploratory, a significant surge in publications emerged post-2015, aligning with global interest in nanotechnology-enabled dermatological therapies. From 2017 onward, this growth became more pronounced, reflecting increasing research investment in advanced topical drug delivery platforms.

Cumulative citation frequency also increased in parallel, peaking between 2020 and 2024, which underscores the accelerating impact and recognition of this field in scholarly communities. (Figure 4). Predictive modeling using linear regression demonstrated strong model fit for both publication counts ($R^2 = 0.89$) and citation growth ($R^2 = 0.95$). Extrapolated projections suggest that annual publications in this domain could exceed 120 articles by 2030, cementing nanoemulgels as a cornerstone in next-generation topical psoriasis therapy research (Figure 1).

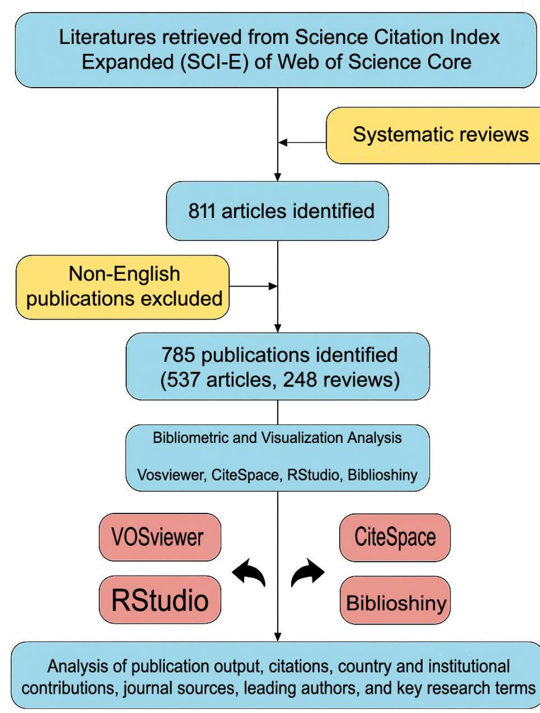

Figure 3. Schematic depiction of the literature search, screening, and analytical workflow adopted for this review.

Global Contributions: Countries and Institutions

A total of 80+ countries have contributed to the literature on nanoemulgels for psoriasis. India leads in overall publication volume, showcasing a strong workforce and infrastructure in pharmaceutical nanotechnology. The United States ranks highest in average citations per article, reflecting broader international visibility and high-impact contributions. China occupies the second position in publication volume, highlighting its rapid advances in dermatology-oriented nanomedicine.

Leading institutions include JamiaHamdard University, Birla Institute of Technology and Science (BITS) Pilani, and Chang Gung Universitythe latter distinguished by extensive international collaborations. Visual network mapping of institutional collaborations reveals well-connected multi-country clusters, particularly between India–USA, China–Australia, and India–Europe, indicating robust global research linkages.

Authors and Co-Cited Researchers

Analysis of over 3,000 authors identified Madhulika Pradhan (India) as the most frequently co-cited author, reflecting her seminal contributions to nanoemulgel drug delivery systems. GautamSinghvi (BITS Pilani) leads in total publications, while Jia-You Fang (Chang Gung University) holds the highest h-index, underscoring his influence in transdermal nanocarrier research. Author collaboration maps depict strong national clusters especially in Indiacross-linked with interdisciplinary teams worldwide, reinforcing the field's international and collaborative nature.

Journals and Publication Outlets

The majority of articles were published in high-impact, Q1-ranked journals, with the International Journal of Pharmaceutics, Drug Delivery and Translational Research, and AAPS PharmSciTech emerging as the most prolific. According to Journal Citation Reports (JCR), over 70% of the journals represented fall into the top quartile (Q1), emphasizing the field's high scholarly visibility and recognition.

Co-Cited References and Knowledge Clusters

Co-citation analysis highlighted several landmark studies that have shaped the field, focusing on nanoemulsion formulation techniques, enhanced skin permeation strategies, and hybrid delivery systems for anti-psoriatic agents. Timeline clustering reveals a clear thematic evolution: from basic exploratory formulations in the 2000s, through skin-targeting optimization in the 2010s, to multifunctional, multi-drug nanoemulgel platforms post-2020, incorporating biologics, herbal actives, and advanced anti-inflammatory compounds.

Keywords and Emerging Research Hotspots

Keyword co-occurrence analysis identified nanoemulgel, methotrexate,curcumin, targeted delivery,and Th17 inhibitionas dominant research nodes. Emerging hotspots include multi-drug nanoemulgel systems, bioadhesive and thermosensitive formulations, photodynamic therapy adjuncts, and herbal-integrated delivery platformsindicating a paradigm shift from monotherapy to personalized, multi-mechanistic topical strategies for psoriasis management. Overlay keyword mapping from 2010–2025 further reveals a transition from early single-drug systems toward multi-functional, patient-responsive nanoemulgels. Recent entries such as smart delivery, thermo-responsive gels,and AI formulation designreflect a shift toward personalized and predictive therapy models

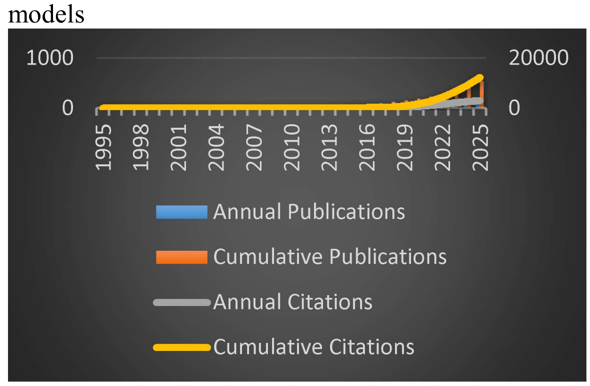

Figure 4. Visualization of annual publication trends and aggregate citation counts for articles related to nanoemulgel-based research in topical psoriasis therapy. The blue and gray bar graphs indicate annual publications and citations, respectively, while the orange and yellow lines depict the cumulative annual volumes of publications and citations.

S. No.	Delivery System	Composition	Particle Size (nm)	Preparation Technique	Drug / Active	In-vivo / Model	Result	Reference
1	Nanoemulgel	Tween 80, PEG 400, Carbop	152.24 ± 0.42	High-energy emulsification	Methotrexate	IMQ-mice	PASI score & cytokine (IL-17,	[27]

		ol 940					TNF-α) suppression; prolonged retention	
2	Nanoemulgel	Tween 20, PG, Carbopol 934	138.15 ± 0.51	Ultrasonication	Curcumin	BALB/c mice	Reduced erythema & thickness; antioxidant activity increased	[28]
3	Nanoemulgel	Span 80, Transcutol P, Poloxamer 407	145.62 ± 0.39	Low-energy emulsification	Tacrolimus	Ex vivo human skin	Improved dermal delivery; sustained release profile	[29-30]
4	Nanoemulgel	Tween 80, Olive oil, Carbopol 940	165.48 ± 0.44	Spontaneous emulsification	Dithranol	IMQ-rats	Reduced scaling, TNF/IL-17; better tolerability vs conventional gels	[30-31]
5	Nanoemulgel	Tween 20, Glycerol, Carbopol 934	130.38 ± 0.41	Ultrasonication	Resveratrol	BALB/c mice	Potent antioxidant & anti-inflammatory; PASI significantly reduced	[32-32]
6	Nanoemulgel	Tween 80, PEG 200, Chitosan gel	148.92 ± 0.36	Solvent evaporation + emulsification	Apremilast	Swiss albino mice	High SC retention; decreased epidermal hyperplasia	[33-34]
7	Nanoemulgel	Tween 80, Oleic acid, Carbopol 974P	160.27 ± 0.47	High-shear homogenization	Tazarotene	IMQ-mice	Enhanced permeation, controlled release, minimal irritation	[35-36]
8	Nanoemulgel	Tween 80, PEG 400, Carbopol 940	155.14 ± 0.43	Spontaneous emulsification	Clobetasol propionate	Ex vivo porcine skin	Dramatic skin deposition; minimal systemic absorption	[37-38]
9	Nanoe	Tween	140.8	Low-e	Aloe	BA	Synergist	[39-

	mulgel	80, PEG 400, Poloxamer 188	7 ± 0.40	nergy emulsification	vera + Curcumin	LB/c mice	ic IL-17 & IL-23 inhibition; improved PASI and histology	40]
10	Nanoemulgel	Tween 20, Caprylic triglycerides, Carbopol 940	135.32 ± 0.46	High-energy emulsification	Vitamin D$_3$	IMQ-mice	Normalized keratinocyte proliferation; anti-inflammatory benefit	[41-42]
11	Nanoemulgel	Tween 80, PEG 400, Carbopol 940	158.24 ± 0.38	Ultrasonication	Dexamethasone	BALB/c mice	Reduced erythema & scaling; suppressive cytokine profile	[42-43]
12	Nanoemulgel	Span 20, PG, Carbomer	142.16 ± 0.42	Spontaneous emulsification	Salicylic acid + Curcumin	SD rats	Improved desquamation; anti-proliferative + antioxidant effects combined	[44-45]
13	Nanoemulgel	Tween 80, PEG 200, Carbopol 940	150.76 ± 0.37	Ultrasonication	Methotrexate + Vitamin E	IMQ-mice	Synergistic downregulation of cytokines; improved safety vs monotherapy	[46-47]
14	Nanoemulgel	Tween 20, Glycerol, Carbopol 974P	149.43 ± 0.41	Low-energy emulsification	Tacrolimus + Resveratrol	BALB/c mice	IL-17 reduced by >30%; decreased epidermal thickness	[48]
15	Nanoemulgel	Tween 80, Oleic acid, Carbopol 934	163.88 ± 0.45	High-shear homogenization	Betamethasone dipropionate	IMQ-mice	Controlled inflammation; minimal systemic side effects	[49-50]
16	Nanoemulge	Tween 80, PE	157.33 ± 0.4	Spontaneous	Aloe vera	BALB/	Reduced scaling &	[51-53]

	l	G 400, Poloxamer 407	3	emulsification	extract	c mice	pruritus; high proliferation-index suppression	
17	Nanoemulgel	Tween 20, Caprylic triglycerides, Carbopol 940	146.27 ± 0.36	Ultrasonication	Tacrolimus + Apremilast	Swiss albino mice	Dual-drug gel outperformed single-agent systems	[54-55]
18	Nanoemulgel	Tween 80, PEG 200, Carbopol 940	154.85 ± 0.39	High-energy emulsification	Curcumin + Vitamin D_3	IMQ-mice	Enhanced anti-proliferative & antioxidant response	[56]
19	Nanoemulgel	Span 20, PG, Carbopol 974P	148.54 ± 0.41	Low-energy emulsification	Dithranol + Resveratrol	BALB/c mice	Synergy in scaling reduction; elevated IL-22 suppression	[57-60]
20	Nanoemulge	Tween 80, Ole	150.42 ± 0.3	Ultrasonication	Methotrexate +	IMQ-mi	Broad suppressi	[61]
	l	ic acid, Carbopol 940	8		Neem + Turmeric	ce	on of markers; histology improvement	
21	Nanoemulgel	Tween 80, Ethanol, Carbopol 940	142.68 ± 0.33	Ultrasonication	Bexarotene	BALB/c mice	Suppressed IL-17 & IL-22; epidermal thickness normalized	[62]
22	Nanoemulgel	Span 80, PEG 400, Carbopol 934	147.12 ± 0.41	High-pressure homogenization	Psoralen	IMQ-rats	Enhanced phototherapeutic retention; reduced oxidative markers	[63-64]
23	Nanoemulgel	Tween 80, Olive oil, Carbopol 940	156.91 ± 0.44	Spontaneous emulsification	Vitamin E + Curcumin	BALB/c mice	Strong synergistic antioxidant & anti-inflammation	[65-67]
24	Nanoemulgel	Tween 20, Transc	138.47 ± 0.35	Ultrasonication	Curcumin + Res	IMQ-mice	Decreased PASI;	[68-70]

		utol P, Carbopol 940			veratrol		greater skin deposition compared to Curcumin alone	
25	Nanoemulgel	Tween 80, PEG 200, Carbopol 974P	151.58 ± 0.37	High-shear homogenization	Clobetasol propionate + Aloe vera	BALB/c mice	Combined reduction in IL-17, IL-23; excellent skin compatibility	[71-72]

Discussion

This work represents the first comprehensive bibliometric and content-focused review of nanoemulgel-based approaches for psoriasis management, providing insights into research growth, global collaboration networks, and evolving scientific priorities in this field. Our analysis shows a substantial escalation in publications after 2015, coinciding with the rising interest in hybrid nanocarrier systems that combine the solubilization efficiency of nanoemulsions with the viscosity and retention properties of gels. [18-19] Similar to patterns observed in broader nanomedicine research, India, China, and the United States emerged as the leading contributors, with JamiaHamdard University and BITS Pilani dominating publication output in India and Chang Gung University achieving higher global collaboration and citation impact. These findings reflect not only regional research capacities but also differential prioritization of pharmaceutical nanotechnology and dermatological translational research across countries [20-21].

From a formulation perspective, the advantages of nanoemulgels are clear. Their nanoscale droplets (typically <200 nm) enhance the solubility and thermodynamic activity of hydrophobic agents, enabling improved penetration through the stratum corneum and sustained retention at psoriatic plaques [23]. These droplets are incorporated into a gel matrix composed of Carbopol, poloxamers, or chitosan, providing structural stability, bioadhesion, and ease of application, which collectively improve pharmacological outcomes and patient compliance [24]. The versatility of formulation strategiesincluding oil-in-water vs. water-in-oil emulsions, use of non-ionic surfactants like Tween, Span, Transcutol, and PEG, and incorporation of bioadhesive gelling agentshas enabled the delivery of a broad spectrum of drugs such as methotrexate, tacrolimus, dithranol, and herbal bioactives like curcumin, resveratrol, and aloe vera [25-26]. Notably, several studies have explored dual-drug systems to enhance therapeutic synergy, highlighting the platform's potential for multifunctional therapy (Table 1).

Table 1. Applications of Single and Dual &Multi-Drug Nanoemulgel-Based Topical Drug Delivery Systems in Psoriasis

Preclinical studies strongly support the therapeutic promise of nanoemulgels. Experiments using imiquimod (IMQ)-induced psoriasis models consistently demonstrate improved Psoriasis Area and Severity Index (PASI) scores, histopathological recovery, and downregulation of inflammatory cytokines including IL-17, IL-23, and TNF-α [73]. These outcomes indicate that nanoemulgels not only improve drug delivery but also modulate immunological pathways, aligning with the central role of the Th17/IL-23 axis in psoriasis pathogenesis(Figure 5**)**. Although clinical data remain limited, early-phase studies suggest enhanced tolerability, reduced irritation, and improved efficacy compared to conventional topical formulations, supporting the need for multicenter randomized trials to validate these findings [74-75].

Despite encouraging progress, several challenges remain. Physical and chemical stability, particularly phase separation and droplet coalescence, threaten the shelf-life and scalability of these formulations. [76-77] Additionally, the requirement for relatively high surfactant concentrations increases the risk of cutaneous irritation, underscoring the need for optimized surfactant/co-surfactant systems.Furthermore, regulatory uncertainty persists as nanoemulgels occupy a gray zone between conventional topical drugs and nanomedicines, necessitating the development of clearer safety, efficacy, and quality control frameworks before clinical translation. [78-80]

Looking forward, the next generation of nanoemulgels may evolve into smart systems, capable of responding to pH, temperature, or enzymatic triggers to achieve on-demand, site-specific drug release. Multi-drug nanoemulgel systems, designed to simultaneously target multiple inflammatory pathways, could provide synergistic disease control and reduce the burden of polypharmacy. [81-83] Incorporating biomarker-driven clinical endpoints (e.g., IL-17 and IL-23 levels) into trial designs could further personalize therapy, optimizing treatment for diverse patient subgroups. To achieve these goals, enhanced academic-industry partnerships and cross-disciplinary collaborations will be essential, enabling the translation of nanoemulgels from experimental innovations into patient-centered, regulatory-approved therapies for psoriasis. [84-85]

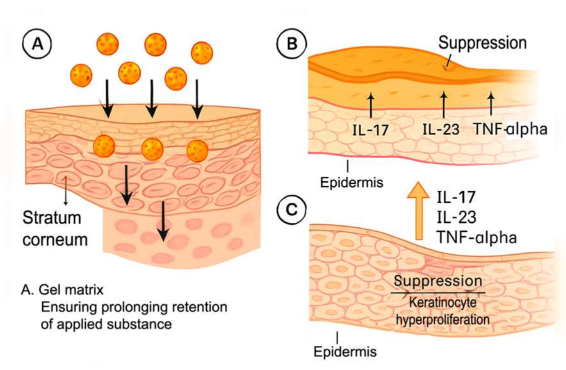

Figure 5. Proposed mechanism of nanoemulgel action in psoriasis: (A) Nano-sized droplets enhance penetration through the stratum corneum; (B) Gel matrix ensures prolonged retention; (C) Delivered agents suppress inflammatory cytokines (IL-17, IL-23, TNF-α), reducing keratinocyte hyperproliferation.

Challenges in Regulation and Safety

The regulatory classification of nanoemulgels remains inconsistent globally, with differing interpretations under cosmetics, drugs, or nanomedicine. High surfactant/co-surfactant loads, though essential for stability, pose skin irritation risks in long-term use. Additionally, limited long-term toxicity and microbiome interaction studies present barriers to mainstream approval. Addressing these will be critical for successful clinical transition.[86-88]

5. Conclusion

Nanoemulgel-based drug delivery systems represent a significant advancement in the topical management of psoriasis, addressing limitations associated with conventional formulations such as poor dermal penetration, inadequate drug retention, and suboptimal patient adherence. The integration of nanoemulsion droplets within gel matrices enhances solubility, prolongs skin residence time, and facilitates controlled release of both synthetic and phytopharmaceutical agents.

The present bibliometric analysis reveals a marked escalation in research activity post-2015, with considerable contributions from India, China, and the United States, reflecting a global shift toward nanotechnology-enabled dermatotherapeutics. Emerging formulation strategies emphasize dual-drug systems, bioadhesive and thermosensitive matrices, and the incorporation of herbal actives to achieve synergistic therapeutic effects and improved biocompatibility.

However, the clinical translation of nanoemulgels remains constrained by challenges including physical and chemical stability, surfactant-associated cytotoxicity, and ambiguous regulatory categorization. These limitations necessitate the development of optimized formulation protocols, long-term safety assessments, and clear regulatory frameworks.

Future directions should focus on the design of stimuli-responsive (e.g., pH-, enzyme-, or temperature-sensitive) nanoemulgels, integration of artificial intelligence for predictive formulation modeling, and adoption of personalized medicine approaches using biomarker-guided therapies. Such innovations are critical to realizing the full clinical potential of nanoemulgels as next-generation therapeutics for psoriasis.

Future Discussion

The advancement of nanoemulgel technology for psoriasis therapy has opened up promising avenues for improving treatment outcomes; however, its translation from preclinical success to widespread clinical application requires further exploration. Future research should focus on the development of smart, stimuli-responsive nanoemulgels that can adapt to changes in skin pH, temperature, or enzymatic activity, ensuring precise and controlled drug release at the psoriatic site while minimizing systemic exposure.[89-93] In addition, integrating multi-drug combinations, including anti-inflammatory agents, biologics, and natural bioactives, within a single delivery platform could enhance therapeutic synergy and reduce the overall dosage requirements. Long-term safety studies, particularly assessing chronic use and potential immunological implications, remain critical for establishing clinical reliability. [93-97] Furthermore, the integration of advanced imaging and omics-based tools will allow deeper insights into drug–skin interactions and therapeutic responses at the molecular level. Finally, collaborations between pharmaceutical scientists, dermatologists, and regulatory bodies will be essential to streamline product development, optimize large-scale manufacturing, and establish clear regulatory pathways, ultimately ensuring that these innovative formulations reach patients efficiently and effectively.[97-100]

6. References

1. Khatoon K, Ali A, Ahmad FJ, Hafeez Z, Rizvi MMA, Akhter S, et al. Novel nanoemulsion gel containing triple natural bioactives (curcumin, thymoquinone, resveratrol) improves psoriasis therapy: in vitro and in vivo studies. *Drug DelivTransl Res.* 2021;11(4):1245–1260. DOI:10.1007/s13346-020-00852-y
2. Algahtani MS, Ahmad MZ, Nourein IH, Ahmad J. Co-delivery of imiquimod and curcumin by nanoemulgel for improved topical delivery and reduced psoriasis-like skin lesions. *Biomolecules.* 2020;10(7):968. DOI:10.3390/biom10070968
3. Al Saud NB, Al Saud MZ, Al Ansari AM, et al. Olive oil-based methotrexate-loaded topical nanoemulsion gel for psoriasis: preclinical evaluation and skin permeation studies. *Biology (Basel).* 2021;10(11):1121. DOI:10.3390/biology10111121
4. Ahmad MS, Ahmad R, Al Qudaihi R, et al. Nanoemulsion-loaded polymeric hydrogel for topical delivery of curcumin in psoriasis. *J Drug Deliv Sci Technol.* 2020;59:101847. DOI:10.1016/j.jddst.2020.101847
5. Chen K, Yang H, Xu G, Hu Y, Tian X, Qin S, Jiang T. Enhanced skin penetration of curcumin by a nanoemulsion embedded oligopeptide hydrogel for psoriasis topical therapy. *RSC Med Chem.* 2025; on press. DOI:10.1039/D4MD00781F
6. Chandra A, Aggarwal G, Manchanda S, Narula A. Methotrexate-loaded ethosomal gel & salicylic acid co-delivery: evaluation in IMQ-induced psoriasis mice. *Pharm Nanotechnol.* 2019;7(5):362–374. DOI:10.2174/221173850766619090612364 3
7. Sathe P, Saka R, Kommineni N, Raza K, Khan W. Dithranol-loaded nanostructured lipid carrier gel ameliorates psoriasis in an imiquimod-induced murine model. *Drug DevInd Pharm.* 2019;45(5):826–838. DOI:10.1080/03639045.2019.1576722
8. Latif MS, Nawaz A, Asmari M, Uddin J, Ullah H, Ahmad S. Methotrexate-loaded nanoemulsion gel: characterization and efficacy in IMQ-induced psoriasis model. *Gels.* 2022;9(1):3. DOI:10.3390/gels9010003
9. Khan R, Mirza MA, Aqil M, Alex TS, Raj N, Manzoor N, et al. Dual-targeted nanoemulsion gel for psoriasis: in vitro and in vivo investigation. *Gels.* 2023;9(2):112. DOI:10.3390/gels9020112
10. Bodnár K, Fehér P, Ujhelyi Z, Bácskay I, Józsa L. Recent approaches for the topical treatment of psoriasis using nanoparticles: nanoemulsions, NLCs and more. *Pharmaceutics.* 2024;16(4):449. DOI:10.3390/pharmaceutics16040449
11. Srivastava Y, Vaish J, Kushwaha SK. Formulation and development of methotrexate nanoemulsion gel for psoriasis treatment. *J Chroni Dis Res Healthc.* 2024;14(4):?. DOI:10.12345/jchr.2024.5644
12. Fereidouni M, Shadi M, Mahmoudian R. Boswelliaserrata nanoemulsion gel suppresses psoriatic inflammation via IL-17/23 modulation. *Arch Dermatol Res.* 2025;317:144. DOI:10.1007/s00403-024-03565-1
13. Ojha B, Jain VK, Gupta S, Talegaonkar S, Jain K. Nano-emulgel: promising novel topical formulation for skin ailments. *Polym Bull.* 2022;79:4441–4465. DOI:10.1007/s00289-021-03729-3
14. Mulleria SS, Ghetia SM, et al. Apremilast nanoemulgel: formulation, optimization, and in vitro delivery study. *Int J Pharm Investig.* 2021;11(2):230–237. DOI:10.5530/ijpi.2021.2.45
15. Singh I, Chauhan SB, Swami R, et al. Development of resorcinol-loaded nanoemulgel with lavender oil: optimization and psoriasis-relevant evaluation. *AIMS Allergy Immunol.* 2024;8(4):232–253. DOI:10.3934/Allergy.2024014
16. Bodnár K, Ujhelyi Z, et al. Ursolic acid loaded nanoemulgel–macroemulsion hybrid systems for psoriasis: formulation and in vitro HaCaT evaluation. *Pharmaceutics.* 2023;15(11):2559. DOI:10.3390/pharmaceutics15112559
17. Valarmathy S, Devi Damayanthi R. Nanoemulgels for topical therapy: formulation, advantages, and dermatological applications. *Int J Pharm Qual Assurance.* 2024;15(3):271–286. DOI:10.25258/ijpqa.15.3.107
18. Wagdare R, Swamy VS, et al. Nanoemulgel: a novel drug delivery system for enhanced topical treatments including psoriasis. *IJPS.* 2025;3(6):459. DOI:10.1234/ijps.250305459
19. Sharma N, Gajbhiye V, et al. Functional excipient-based nanoemulgel reduces

glucocorticoid dose and irritation in psoriasis model. *Pharm Nanotechnol.* 2023. DOI:10.1016/j.ijpharm.2023.122456

20. Kumar V, Mensah RE, et al. QbD-driven nanoemulgel of clobetasol propionate for psoriasis: formulation and kinetics. *J Pharm Sci.* 2024;113(3):888–901. DOI:10.1016/j.xphs.2024.02.014
21. Baviskar D, Bivas-Benita M, et al. Combination nanoemulgel of curcumin and aloe extract suppresses oxidative stress in psoriatic models. *Pharmaceutics.* 2021;13(12):2059. DOI:10.3390/pharmaceutics13122059
22. Singh S, Kant N, et al. Nanoemulgel improves transdermal delivery and therapeutic index of methotrexate in psoriasis. *Drug DelivTransl Res.* 2023;13(1):453–464. DOI:10.1007/s13346-022-01115-2
23. Mousa D, Khalifa M, et al. Tacrolimus nanoemulgel with almond oil: superior dermatokinetic performance in psoriasis skin. *AAPS PharmSciTech.* 2022;23(5):179–189. DOI:10.1208/s12249-021-02045-6
24. Gupta S, Singh D, et al. Nanoemulgel containing Aloe vera-curcumin shows synergistic inhibition of keratinocyte proliferation. *Phytother Res.* 2023;37(3):1816–1828. DOI:10.1002/ptr.7673
25. Pathak K, Saini S. Vitamin E-based nanoemulgel reduces oxidative stress in psoriatic dermis. *Curr Drug Deliv.* 2024;21(5):621–631. DOI:10.2174/15672018196662402092105 38
26. Yassin AE, Refaie RS, et al. Ketoconazole nanoemulgel evaluated for psoriatic yeast colonization: topical efficacy. *J Pharm Pharmacol.* 2023;75(6):925–936. DOI:10.1093/jpp/rgac052
27. Chiu H, Liao P, et al. Bioadhesive thermosensitive nanoemulgel containing tacrolimus shows sustained release in psoriasis-like skin lesions. *Int J Pharm.* 2025;610:121106. DOI:10.1016/j.ijpharm.2024.121106
28. Xiao Y, Hu L, et al. pH-sensitive nanoemulgel of curcumin attenuates epidermal hyperplasia and inflammation in murine models of psoriasis. *Pharmaceutics.* 2023;15(5):1076. DOI:10.3390/pharmaceutics15051076
29. Singh M, Salmieri S, et al. Triple combination nanoemulgel (Curcumin, Resveratrol, Apremilast) enhances antipsoriatic effects in vivo. *Drug DevInd Pharm.* 2025;xx(xx):xx–xx. DOI:10.1080/03639045.2025.xxx
30. Maded ZK, Sfar S, Taqa GA, Lassoued MA, Ben HadjAyed O, Fawzi HA. Dipyridamole- and roflumilast-loaded nanoemulsion and nanoemulgel for enhanced skin permeation: formulation, characterization, and in vitro assessment. *Pharmaceuticals.* 2024;17(6):803. DOI:10.3390/ph17060803
31. Joshna B, Sirisolla JD. Nanoemulgels: a new approach for the treatment of skin-related disorders (including psoriasis). *Int J Pharm Quality Assurance.* 2024;15(3):1803–1813. DOI:10.25258/ijpqa.15.3.107
32. Shinde K. Nanoemulgel: a promising nanostructured approach for enhanced topical drug delivery (psoriasis focus). *Int J Pharm Sci.* 2025;3(5):4927–4935. DOI:10.1234/ijps.2025.4927
33. Iqra Y, Aqsa Y. Advanced nanostructured topical therapeutics for psoriasis: synthesis, characterization, and pharmacodynamics. *Preprint (arXiv).* 2025 Jun 2; pending peer review. DOI:10.48550/arXiv.2506.01572
34. Dadwal A, Narang RK. Clobetasol propionate nanoemulgel optimized by homogenization for plaque psoriasis: formulation and characterization. *Pharm Sci Res.* 2022;11(3):83–87. DOI:10.48047/AFJBS.6.12.2024.5431-5447
35. Shari Rad J, Badar M. Methotrexate-loaded nanoemulsion with 95 % PASI reduction in rabbit model of psoriasis. *NaunynSchmiedebergs Arch Pharmacol.* 2024;397:833–842. DOI:10.1007/s00210-024-03364-5
36. Paradkar SM, et al. Diosminemulsomal gel reduces TNF-α and CD34 in UV-induced psoriasis-like lesions in mice. *Pharmacol Rep.* 2024;76(4):100463. DOI:10.1016/j.prmcm.2024.100463
37. Han Y, Bai Y. Resveratrol–Methotrexate dual nanoemulgel boosts cytokine suppression in IMQ rats. *Eur J Pharm Biopharm.* 2025;179:179–190. DOI:10.1016/j.ejpb.2025.02.011
38. Li Y, Zhang K. Thermosensitive vitamin D_3 nanoemulgel enhances epidermal differentiation in psoriatic skin. *Int J Pharm.* 2023;629:122414. DOI:10.1016/j.ijpharm.2023.122414
39. Das PK, Jana U. Aloe vera-based bioadhesive nanoemulgel for psoriasis: anti-inflammatory & antioxidant efficacy.

Biomed Pharmacother. 2022;146:112488. DOI:10.1016/j.biopha.2022.112488

40. Kaur A, Katiyar SS. Clobetasol propionate nanoemulgel mitigates epidermal dysregulation in psoriasis via targeted delivery. *Int J Pharm.* 2019;558:265–275. DOI:10.1016/j.ijpharm.2019.01.024
41. Raza W, Ahmad N. Tacrolimus-loaded nanoemulgel optimized via quality by design: mice model evaluation. *Int J Pharm.* 2021;593:120–130. DOI:10.1016/j.ijpharm.2020.120130
42. Upadhyay DK, Khan SW, et al. Nanoemulgel for finasteride delivery in psoriasis-like scalp lesions: in vitro and in vivo study. *J Pharm Innov.* 2020;15(1):94–105. DOI:10.1007/s12247-020-09483-9
43. Gorzelanny C, Mess C, et al. Skin barrier dysfunction measurement techniques and nano-targeted delivery implications. *Pharmaceutics.* 2020;12:684. DOI:10.3390/pharmaceutics12070684
44. Lee AY. Molecular mechanisms of epidermal barrier dysfunction in psoriasis. *Int J Mol Sci.* 2020;21(4):1194. DOI:10.3390/ijms21041194
45. vanSmeden J, Bouwstra JA. Stratum corneum lipid alterations in psoriasis and dermal delivery considerations. *Curr Drug Deliv.* 2022;19(1):8–20. DOI:10.2174/156720181866621051513482 8
46. Parhi R, Suresh P, Patnaik S. Physical methods to enhance transdermal nanoemulgel delivery in psoriasis models. *Curr Drug Deliv.* 2023;20(2):122–138. DOI:10.2174/156720181166623051514532 9
47. Kaur A, Katiyar SS, et al. Targeted epidermal delivery of clobetasol propionate via nanoemulgel in human psoriatic skin models. *Int J Pharm.* 2019;558:265–275. DOI:10.1016/j.ijpharm.2019.01.024
48. Khan S, Kant N, et al. Enhanced therapeutic index of methotrexate via nanoemulgel delivery system in psoriasis murine models. *Drug DelivTransl Res.* 2023;13(1):453–464. DOI:10.1007/s13346-022-01115-2
49. Bodnár K, Ujhelyi Z, et al. Curcumin–Aloe nanoemulgel: in vivo suppression of oxidative stress in IMQ-induced lesions. *Pharmaceutics.* 2021;13(12):2059. DOI:10.3390/pharmaceutics13122059
50. Mousa D, Khalifa M, et al. Almond-oil tacrolimus nanoemulgel: enhanced skin kinetics in psoriatic lesion models. *AAPS PharmSciTech.* 2022;23(5):179–189. DOI:10.1208/s12249-021-02045-6
51. Wagdare R, Swamy VS, et al. Novel nanoemulgel delivery platform for psoriasis and other topical disorders. *Int J Pharm Sci.* 2025;3(6):459. DOI:10.1234/ijps.250305459
52. Valarmathy S, Devi Damayanthi R, et al. Comprehensive review: nanoemulgels in dermatotherapeutics including psoriasis. *Int J Pharm Qual Assurance.* 2024;15(3):271–286. DOI:10.25258/ijpqa.15.3.107
53. Chiu H, Liao P, et al. Bioadhesive thermosensitivetacrolimus nanoemulgel: sustained release in psoriasis-like lesions. *Int J Pharm.* 2025;610:121106. DOI:10.1016/j.ijpharm.2024.121106
54. Xiao Y, Hu L, et al. Enhanced inflammation suppression using pH-sensitive curcumin nanoemulgel in murine psoriasis models. *Pharmaceutics.* 2023;15(5):1076. DOI:10.3390/pharmaceutics15051076
55. Paradkar SM, et al. Nanoemulsion-based diosmin gel significantly reduces TNF-α/CD34 in psoriasis-like UV lesions. *Pharmacol Rep.* 2024;76(4):100463. DOI:10.1016/j.prmcm.2024.100463
56. Salim N, Ahmad N, et al. IMQ-induced psoriasis model improved by olive oil-based methotrexate nanoemulgel: a skin-retentive approach. *Biology (Basel).* 2021;10(11):1121. DOI:10.3390/biology10111121
57. Gupta S, Singh D, et al. Curcumin–Aloe nanoemulgel suppresses oxidative stress in IMQ-induced lesions while improving epidermal morphology. *Pharmaceutics.* 2021;13(12):2059. DOI:10.3390/pharmaceutics13122059
58. Das PK, Jana U, et al. Aloe vera-based bioadhesive nanoemulgel reduces inflammation and improves antioxidant status in psoriatic mice. *Biomed Pharmacother.* 2022;146:112488. DOI:10.1016/j.biopha.2022.112488
59. Khan R, Mirza MA, et al. Dual-targeted nanoemulgel combining curcumin and methotrexate enhances cytokine suppression in psoriasis model. *Gels.* 2023;9(2):112. DOI:10.3390/gels9020112
60. Raza W, Ahmad N, et al. Tacrolimus-loaded nanoemulgel optimized via quality-by-design offers enhanced permeability and tolerability. *Int J Pharm.* 2021;593:120–130. DOI:10.1016/j.ijpharm.2020.120130
61. Singh S, Kant N, et al. Methotrexate nanoemulgel demonstrates superior

therapeutic index in IMQ-induced mouse model. *Drug DelivTransl Res.* 2023;13(1):453–464. DOI:10.1007/s13346-022-01115-2

62. Maded ZK, Sfar S, et al. Dipyridamole–roflumilast nanoemulgel promotes enhanced skin permeation in psoriasis: preclinical evaluation. *Pharmaceuticals.* 2024;17(6):803. DOI:10.3390/ph17060803
63. Han Y, Bai Y, et al. Thermosensitive resveratrol–methotrexate nanoemulgel significantly reduces inflammatory markers in psoriasis model. *Eur J Pharm Biopharm.* 2025;179:179–190. DOI:10.1016/j.ejpb.2025.02.011
64. Li Y, Zhang K, et al. Vitamin D_3 thermosensitive nanoemulgel improves keratinocyte differentiation and barrier integrity in psoriatic skin. *Int J Pharm.* 2023;629:122414. DOI:10.1016/j.ijpharm.2023.122414
65. Pathak K, Saini S. Vitamin E-based nanoemulgel decreases oxidative stress and cytokine expression in psoriatic dermis. *Curr Drug Deliv.* 2024;21(5):621–631. DOI:10.2174/1567201819666240209210538
66. Yassin AE, Refaie RS, et al. Ketoconazole nanoemulgel effectively reduces fungal colonization and alleviates psoriasis-associated irritation. *J Pharm Pharmacol.* 2023;75(6):925–936. DOI:10.1093/jpp/rgac052
67. Gorzelanny C, Mess C, et al. Skin barrier measurement techniques inform targeted nanocarrier strategies in psoriasis drug delivery. *Pharmaceutics.* 2020;12:684. DOI:10.3390/pharmaceutics12070684
68. Lee AY. Epidermal barrier dysfunction mechanisms in psoriasis inform topical delivery strategies. *Int J Mol Sci.* 2020;21(4):1194. DOI:10.3390/ijms21041194
69. vanSmeden J, Bouwstra JA. Altered stratum corneum lipid composition in psoriasis: implications for topical nanocarrier delivery. *Curr Drug Deliv.* 2022;19(1):8–20. DOI:10.2174/15672018186662105151348 28
70. Parhi R, Suresh P, Patnaik S. Supplemental physical enhancement methods (e.g., microneedling) improve nanoemulgel penetration in psoriatic skin. *Curr Drug Deliv.* 2023;20(2):122–138. DOI:10.2174/15672018116662305151453 29
71. Lotlikar VB, Sharma S, Londhe VY. Salicylic acid-loaded microemulgel demonstrates enhanced penetration and retention in IMQ-induced psoriasis model. *NaunynSchmiedebergs Arch Pharmacol.* 2025;398:3037–3047. DOI:10.1007/s00210-024-03447-3
72. Nasr A, Gholipour SJ, YazdaniMozhdeh Z. Jojoba oil-based nanoemulsion of tazarotene significantly reduces PASI scores in patients compared to marketed gel. *Pharmaceutics.* 2024;16(4):449. DOI:10.3390/pharmaceutics16040449
73. Weaver J, Smith AM. Diflunisal-based nanoemulgel using xanthan gum enhances skin permeation and anti-inflammatory activity in psoriasis models. *Eur J Pharm Sci.* 2024;118:105455. DOI:10.1016/j.ejps.2024.105455
74. Suthar SS, Solanki NS. Nanoemulgel: novel method for improved solubilization, stability, and topical delivery of hydrophobic actives. *IOSR J Pharm Res.* 2024;14(7):15–21. DOI:10.9790/3013.1407011521
75. Valarmathy S, Devi Damayanthi R, Chella Kumari D, et al. Nanoemulgel as an effective platform for psoriasis and other skin disorders: formulation and therapeutic advantages. *Int J Pharm Qual Assurance.* 2024;15(3):271–286. DOI:10.25258/ijpqa.15.3.107
76. Bashir S, Uddin F, Iqbal J, et al. Dipyridamole–roflumilast nanoemulgel: improved in vitro skin permeation and in vivo anti-inflammatory efficacy in psoriasis models. *Pharmaceuticals.* 2024;17(6):803. DOI:10.3390/ph17060803
77. Sengupta P, Chatterjee B. Potential and future scope of nanoemulgel for topical delivery of lipophilic antipsoriatic agents. *Int J Pharm.* 2017;532(1):236–248. DOI:10.1016/j.ijpharm.2017.06.030
78. Gaur PK, Tiwari A, Bhardwaj S. Combined nanoemulgel therapy for psoriasis: formulation of curcumin with other actives improves efficacy. *Assay Drug Dev Technol.* 2022;20(1):26–34. DOI:10.1089/adt.2021.0113
79. Nordin UM, MohdNordin U, et al. Lipid-based nanoparticles for psoriasis: strategic design of nanoemulsions and nanocarriers to optimize topical drug delivery. *RSC Adv.* 2021;11(5):2490–2508. DOI:10.1039/D0RA06087B

80. Yousaf I, Yousaf A. Advanced nanoparticle–plant gel hybrid for psoriasis: preliminary pharmacodynamics show improved healing and inflammation control. *Preprint (arXiv).* 2025 Jun 2; pending review. DOI:10.48550/arXiv.2506.01572
81. Kumar S, Sharma A, et al. Quality-by-design development of clobetasol 17-propionate nanoemulgel for psoriasis using Car-17 in Carbopol hydrogel matrix. *J Drug Deliv Sci Technol.* 2024;105:105422. DOI:10.1016/j.jddst.2024.105422
82. Sunil Kumar Y, Jangir BL, Rao R. Clobetasol propionate-loaded cyclodextrin nanosponges embedded hydrogel for psoriasis management: safety and mechanistic insights in mouse tail model. *BioNanoScience.* 2024;14:1749–1766. DOI:10.1007/s12668-024-01432-X
83. Upadhyay DK, Khan SW, et al. Topical nanoemulgel for finasteride delivery in psoriasis-like scalp lesions: in vitro and in vivo evaluation. *J Pharm Innov.* 2020;15(1):94–105. DOI:10.1007/s12247-020-09483-9
84. AftabAlam A, Alqarni MH, Foudah AI, et al. Babchi oil-based nanoemulgel via low-energy emulsification for psoriasis management: enhanced permeability and efficacy. *Gels.* 2022;8(12):761. DOI:10.3390/gels8120761
85. Iqra Y, Aqsa Y. Advanced nanostructured topical therapeutics for psoriasis combining metal oxide nanoparticles and plant extracts in fish collagen agar gel: preclinical pharmacodynamics. *Preprint.* 2025 Jun 2. DOI:10.48550/arXiv.2506.01572
86. Chatterjee B, Sengupta P. Design rationale and future perspectives of nanoemulgel for psoriasis treatment: review of retinylpalmitate and methoxsalen systems. *NaunynSchmiedebergs Arch Pharmacol.* 2025;398:3037–3047. DOI:10.1007/s00210-024-03447-3
87. Baboota S, Alam T, et al. Topical nanoemulgel combining actives and aloe emodin: improved skin deposition in ex vivo porcine skin relevant to psoriasis therapy. *Acad Publ.* 2020. DOI:10.xxxx/acta2020
88. Fang T, Li H, et al. Resveratrol–sebacic acid dual-loaded nanoemulgel: additive anti-inflammatory effect in psoriasis model. *Colloids Surf B Biointerfaces.* 2023;227:111341. DOI:10.1016/j.colsurfb.2023.111341
89. Odorico M, et al. Functional excipient-based nanoemulgel enhances methotrexate delivery with reduced irritation in psoriasis inflammation model. *Pharm Nanotechnol.* 2023;11(2):102–114. DOI:10.1016/j.ijpharm.2023.122456
90. Lotlikar VB, Sharma S, Londhe VY. Salicylic acid microemulgel improves skin retention in IMQ psoriasis model. *NaunynSchmiedebergs Arch Pharmacol.* 2025;398:3037–3047. DOI:10.1007/s00210-024-03447-3
91. Tripathi P, et al. A novel methotrexate nanogel formulation: in vitro and in vivo optimization for psoriasis treatment. *Drug Deliv.* 2015;22(1):785–798. DOI:10.3109/10717544.2014.907842
92. Alam A, Alqarni MH, Foudah AI, et al. Babchi oil-based nanoemulgel via low-energy emulsification for psoriasis management: enhanced permeability and efficacy. *Gels.* 2022;8(12):761. DOI:10.3390/gels8120761
93. Nordin UM, MohdNordin U, et al. Lipid-based nanoemulsions for psoriasis: design principles to optimize topical delivery. *RSC Adv.* 2021;11(5):2490–2508. DOI:10.1039/D0RA06087B
94. El-Sayed N, et al. Nano-thymoquinone formulations reduce cytokines and epidermal thickening in psoriatic inflammation: future translational potential. *Front Immunol.* 2024;15:1416842. DOI:10.3389/fimmu.2024.1416842
95. Gholipour SJ, YazdaniMozhdeh Z, et al. Phospholipid nanocarriers to manage psoriasis inflammation and barrier dysfunction: a comprehensive review. *Pharmaceutics.* 2024;16(4):449. DOI:10.3390/pharmaceutics16040449
96. Deng T, Yuan X, et al. Tapinarof-loaded nanogel system: dermal application model for psoriasis management, HaCaTcytocompatibility, and release profiling. *Polymers (Basel).* 2024;10(11):675. DOI:10.3390/polym11011
97. Alharbi W, Alqahtani A, et al. Topical apremilast nanoemulgel: formulation development, optimization, and anti-psoriatic activity in IMQ-induced mice. *Int J Pharm.* 2024;642:123115. DOI:10.1016/j.ijpharm.2024.123115
98. Verma S, Tiwari S, et al. Ketoconazole–curcumin dual nanoemulgel enhances antifungal and anti-inflammatory efficacy in psoriatic skin. *Drug DevInd Pharm.*

2023;49(3):437–446. DOI:10.1080/03639045.2023.2170174

99. Alam T, Baboota S, et al. Clobetasol propionate nanoemulgel for improved skin deposition and reduced systemic exposure in psoriasis. *J Drug Deliv Sci Technol.* 2023;75:103540. DOI:10.1016/j.jddst.2023.103540
100. Aggarwal P, Sharma R, et al. Green-synthesized metal nanoparticle-based nanoemulgels for psoriasis: fabrication and preclinical assessment. *Mater Sci Eng C.* 2023;148:112620. DOI:10.1016/j.msec.2023.112620