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"Nanostructured Lipid Carriers for the treatment of psoriasis: An Overview"

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Abstract:

Psoriasis, a chronic immune-mediated inflammatory skin disease, affects 2-4% of the global population, with a higher prevalence in Western regions. While not fatal, psoriasis significantly impacts patients' quality of life and is associated with an elevated risk of comorbidities, including diabetes, cancer, and cardiovascular illnesses. This review explores the epidemiological variations, genetic influences, and triggers contributing to psoriasis development. The gold standard for determining severity is the Psoriasis Area and Severity Index (PASI) score, guiding treatment decisions. Traditional treatments involve topical and systemic approaches, with topical corticosteroids being a cornerstone. However, recent advances have introduced Nanostructured Lipid Carriers (NLCs) as a promising drug delivery system for improved psoriasis treatment. NLCs offer advantages such as increased drug loading capacity, regulated release timelines, and extended shelf life. The review also discusses other lipid-based carriers, such as liposomes, transferosomes, and niosomes, along with metallic and polymeric nanoparticles, highlighting their potential in psoriasis management. Current treatment modalities aim to alleviate symptoms, but there is no cure for psoriasis. Future perspectives emphasize the potential of NLCs, calling for more clinical studies to validate their therapeutic efficacy and ensure safety. Collaboration among regulatory bodies is essential to establish guidelines for nano-formulation manufacturing. The evolving landscape signifies a promising era for personalized and efficient psoriasis management, leveraging innovative drug delivery systems to enhance treatment outcomes.

Key words: Nanostructured Lipid Carriers (NLCs), Psoriasis, Lipid carries; psoriasis management.

Introduction:

One chronic immune-mediated inflammatory skin disease is psoriasis. According to clinical descriptions, it manifests as the development of tiny, restricted patches that cover various bodily surface regions (Menter, Gelfand, et al., 2020). Worldwide, 2-4 percent of people suffer with psoriasis. Western states are more affected than the others (Vijayalakshmi, Ravichandiran, Velraj, Nirmala, & Jayakumari, 2012). It has been noted that psoriatic arthritis patients are more likely to develop cutaneous psoriasis.

While psoriasis is not fatal, those who have it have been found to have a higher risk of diabetes, cancer, and cardiovascular illnesses. In addition to impairing quality of life, psoriasis exacerbates psychological stress. Furthermore, the patient's economy is impacted by the direct and indirect financial costs of managing their illness (Bessar et al., 2016).

Geographic variations in the incidence rate (Rendon & Schäkel, 2019) are epidemiologically linked to racial characteristics, genetic background, way of life, and cuisine (Fernández-Armenteros et al., 2019). According to reports, the prevalence of psoriasis varies from 0.91% to 8.5% in adults and from 0 to 2.1% in children (Lin, Chang, & Fang, 2016). It generally shows a higher prevalence among Caucasian and Scandinavian individuals, especially in high-income nations, but a lower occurrence in Asian and certain African communities (Parisi et al., 2020). However, Parisi et al. observed that most low-income nations did not disclose the epidemiology of psoriasis in their country, hence the true statistic regarding its worldwide incidence is not exact.

The illness may develop gradually or may be brought on by a number of recognized triggers. Psoriasis conditions are said to be worsened by viral and bacterial infections. Thirteen In addition, several drugs (including tetracyclines, beta-blockers, lithium antimalarials, and nonsteroidal anti-inflammatory drugs) may exacerbate the condition in adult psoriasis sufferers (Menter, Cordoro, et al., 2020). Additionally, they have been linked to a number of comorbidities associated with psoriasis, such as inflammatory bowel disease, anxiety, depression, dyslipidemia, obesity, type II diabetes, heart disease, and metabolic syndrome.

The highest benchmark for determining how serious a lesion is the Scoring a psoriasis area and severity index (PASI) can help identify the type of psoriasis (light to moderate or moderate to severe). A PASI score of > 10 indicates moderate to severe psoriasis (Fink et al., 2019). Topical treatments are typically advised over systemic treatments for mild to severe cases of psoriasis. In situations when there are moderate to severe medical issues, the latter is preferred (Rapalli et al., 2018). Traditionally, high concentrated therapeutic dosages are applied topically for a predetermined amount of time in order to give antipsoriatic medications (Singhvi, Hejmady, Rapalli, Dubey, & Dubey, 2020). However, this therapy has a number of drawbacks, such as local toxicity from skin irritation and insufficient and inconsistent distribution to the affected region.

The main method used to treat psoriasis is topical treatment. Systemic and cutaneous side effects are the main concerns resulting from the continuous use of synthetic medicines for this lifelong condition. From this angle, flavonoids and polyphenols have emerged as therapeutic substitutes

for these traditional synthetic medications, since they have been shown to be extremely effective for a variety of diseases. Psoriasis is a chronic inflammatory skin disorder and tenacious, with several etiologies. Drugs that target many processes are more effective in treating psoriasis than those that target only one route.

In recent times, biologic medications, also known as biologic agents or biologics, have emerged as a more effective therapy option for moderate to severe cases of psoriasis than alternative methods. This therapy acts systemically while inhibiting inflammatory cytokines at the target region by the use of recombinant proteins. Since the Food and Drug Administration (FDA) authorized etanercept in 2004, the therapy landscape for psoriasis has changed due to the emergence of biologic medicines (Menter et al., 2019).

Lipidic nanocarriers, or dermal application, are among the most promising modern delivery systems being investigated today for efficient administration of active pharmaceuticals, particularly lipophilic therapies, as they combine the benefits of a large drug payload with modified release (Ahad et al., 2017). Furthermore, they possess a unique ability to modify the skin's barrier qualities through an efficient skin contact (Ahad, Aqil, & Ali, 2014). Nanostructured lipid carriers (NLCs) are the most suitable lipid-based carrier system for topical medication delivery (Ali et al., 2019). Due to their tiny size and high lipid content, which produces a homogeneous layer on the stratum corneum, these delivery methods have several benefits for cutaneous drug administration, including strong conclusiveness and perfect adhesion with the skin.

The treatment of psoriasis with nanostructured lipid carriers and its current implications are the main topics of this review paper.

Advantages of NLCs

Increased drug loading capacity (LC) and entrapment efficiency (EE)

Because NLCs use a combination of liquid and solid lipid in their formulations, they provide greater stability, superior release profiles, and extensive drug loading, which addresses the drawbacks of SLNs. Numerous comparative studies between SLNs and NLCs have shown that NLCs are a superior carrier. For instance, despite equal lipid occupation, drug EE in NLCs (95.3%) was greater than in SLNs (87.3%) in the evaluation of ketoconazole inclusion in various formulations of SLNs and NLCs. The chaotic structure caused by the liquid lipid present in NLCs, which gives greater room for drug loading, explains the reason (Dudhipala, Janga, & Gorre, 2018). Since liquid lipids remain liquid during the cooling process, their presence reduces the melting point of the systems, which is advantageous for lipophilic compounds that dissolve readily. As a result, NLCs also stop pharmaceuticals from extruding right away, maintaining the medications' high loading capacity.

Regulation of the drug's release timeline

NLCs have a release profile with a biphasic release pattern, bursting in the beginning and maintaining a steady state in the end. The liquid lipid located in the outermost layers of the NLCs produces drug-enriched packing, which causes the matrix to be eroded by lipolysis or to burst drug release initially (Irby, Du, & Li, 2017).

Solid core lipid discharge medications regularly come next. Using this capability, one may create NLCs with the required release patterns by adjusting the ratio of liquid to solid lipid content. Additionally, because NLCs have a bigger surface area than SLNs, their smaller size also benefits from a speedier release.

Extended shelf life

The development of crystallinity in solid lipid molecules by recrystallization after prolonged storage leads to considerable drug leakage, which makes the suppression of recrystallization in the NLCs delivery system an appealing strategy. But the NLCs model, which is a matrix of liquid and solid lipids, prevents the solid lipid composition from becoming too saturated and keeps the nano-sized mixed drop constant or with very slight variations in polymorphism, enabling the system to store the medicine within for an extended amount of time. After eight weeks of storage at a high temperature of 40 °C, EFV-NLCs were still in EE and LC at 93 percent and 9.2 percent, respectively, in contrast to EFV-SLNs at 88% and 8.6%, respectively. The degree of crystallinity of NLCs was somewhat lower than SLNs, suggesting that EFV should be included (Scioli Montoto, Muraca, & Ruiz, 2020).

pH and preventing the breakdown of enzymes

When it comes to the oral distribution of bioactives like vitamins and peptides that are vulnerable to breakdown by gastric acid and proteases, the stomach's very acidic fluid and the small intestine's enzyme content are often some of the roadblocks. Getting these bioactives into the stomach and then into the duodenum and jejunum is the aim of non-lactating caps. across mice, LBNs were able to penetrate into the base of intestinal villi and the colon and were stable over an 8-hour period across a wide range of gastrointestinal pH values, from 1.2 to 8 (Thuy, Van, Dao, & Lee, 2022).

Obscuring of senses

Sensory masking for medications or meals is a significant benefit of NLCs. Even while these bioactive compounds have health-promoting properties, their taste, odor, color, and texture are unattractive, which restricts their oral usage, particularly for young patients. For example, the phenolic family of chemicals is well known for its antiviral, antioxidant, anti-inflammatory, and even anticancer properties; yet their poor water solubility and unpalatability limit its direct intake. Thus, bioactive substances enclosed in lipid-based nano-delivery systems such as NLCs can be a useful tactic to improve their solubility in the lipid matrix and, advantageously, mask their undesirable sensory attributes while maintaining their nutritional value during processing (Thepwatee et al., 2019).

Limitations of NLCS:

- The manufacture of NLCs lacked clinical and preclinical studies.
- Certain surfactants show irritative and sensitizing activities.
- Cytotoxic effects are noted due on matrix composition and concentration.

Structure of NLCs

NLCs were created as upgrades to SLNs. In contrast, SLNs consist of a single solid lipid, while the NLC lipid phase is composed of both liquid and solid lipids. NLC yields an uneven lattice and an amorphous structure by increasing the amount of liquid lipid, which allows the nanoparticles to stack and take on non-standard shapes. The lipid material of NLCs has greater application potential than that of SLNs since increasing the liquid lipid can increase the solubility of active molecules and promote better encapsulation. In addition to improving drug stability and loading capacity, NLCs reduce medicine leakage during storage.

Three forms of NLC structures were studied by Zheng et al. (2010): numerous types, amorphous, and disordered. The disorderly structure is the first type of structure; it is composed of a mixture of liquid and solid lipids that follow the disordered condition. The presence of the disordered lipid structure increases the ability of the medicine to pass through the lipid layer by forming an interface between the liquid and crystal lipid. The amorphous structure, or non-crystalline state, is the second. The loaded drug's leakage can be completely stopped or much decreased by the absence of a crystalline structure. Crystal formation is inhibited by adding a combination of lipids because crystals develop during cooling.

The third kind is the numerous structures. Compared to the other structures, this one has a larger concentration of liquid lipids. Compared to solid lipid, drug solubility is greater in liquid lipid. As a result, the NLCs can achieve high drug loading and delayed drug release, preventing loss before the solid lipid breaks down (figure 1). The structure of these microemulsions is comparable to that of water-in-oil-in-water (W/O/W).

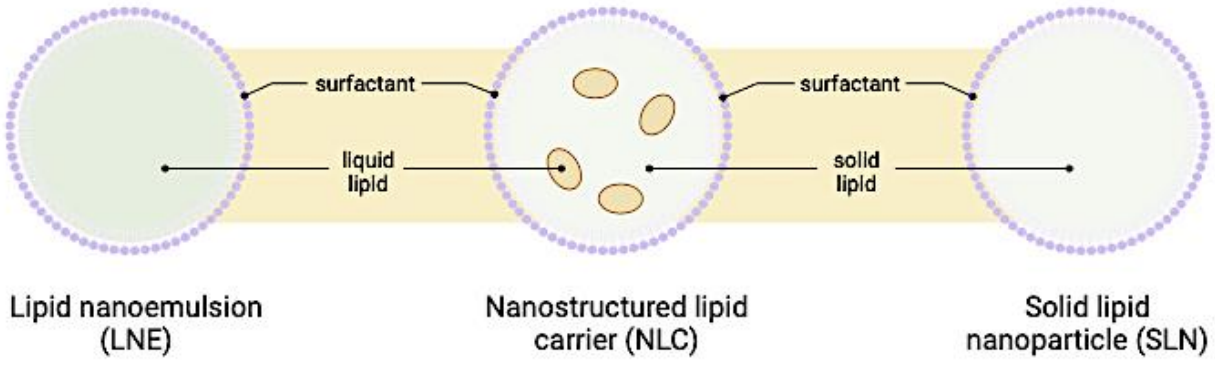

Figure 1. Structure of NLCs

Excipients of NLC formulations

Lipids

The primary component of nanostructure lipid carriers is lipid. Which controls drug loading capacity, action prolongation, and formulation stability. To produce NLC, solid lipids such as fatty acids, waxes, steroids, diglycerides, and monoglycerides have been employed. For the creation of lipid nanoparticles (Noor, Sheikh, Somavarapu, & Taylor, 2017), physiologically acceptable, biodegradable, non-toxic, and generally acknowledged as safe (GRAS) status lipids are favored.

Selecting the right lipids is crucial before using them to create nanoparticulate carriers. The kind and structure of the lipid have an impact on a number of nanocarrier properties. It has been argued that the most practical criterion for selecting an appropriate lipid is the bioactive' solubility or apparent partition coefficient in the lipid. Interpretation is provided by the drug molecules' solubility in lipid, which influences drug loading and encapsulation effectiveness.

The dispersed phase's increased viscosity and higher melting lipid content cause the nano dispersion's average particle size to grow. Other lipid-related factors that may affect the quality of NLC include composition fluctuation, lipid hydrophilicity, and the shape of lipid crystals. Particle size has been reported to increase with a 5- 10% increase in lipid content (Shah, Imran, & Ullah, 2017).

Surfactants

The type and concentration of surfactants affect NLC's quality and efficacy. It has been found that the toxicity, physical stability, and crystallinity of NLC are significantly influenced by the surfactant selected. Surfactant systems also affect the degree of drug dissolution and drug permeability. Surfactants are selected according to their influence on particle size, lipid modification, hydrophilic-lipophilic balance (HLB) value, and mode of administration. Because of their amphipathic character, surface active agents (emulsifiers) are adsorbed on the interface, where they lessen the tension between lipid and aqueous phases (Jaiswal, Gidwani, & Vyas, 2016).

During NLC formation, colloid particle crystallization happens simultaneously with solidification; however, the significant increase in particle surface area that occurs during crystallization causes the system to become unstable. Therefore, surfactant is necessary to enhance the nanoparticles' interface quality in order to achieve stability (Han, Li, Yin, Liu, & Xu, 2008).

Other ingredients

When creating nanostructure carriers, Ionic polymers and organic salts can be utilized as counter-ions to help get around the problem of encasing water-soluble medication molecules. Surface modifiers are another class of excipients used in NLC formulation; they lessen the particles' phagocytic uptake by the macrophages in the reticuloendothelial system (RES). Lipophilic polymers, such as PEG, poloxamines, or poloxamers, are used to coat medicinal compounds to prolong their stay in the systemic circulation. Additional benefits from surface alteration might include improved drug targeting, greater transport across epithelium, and physical stability and biocompatibility (Üner & Yener, 2007).

Methods of preparations of NLCs

High-pressure homogenization technique

For the manufacturing of NLCs on a commercial basis, this method is strong and dependable. The homogenization technique's high pressure allows for the environmentally beneficial avoidance of organic solvent usage in preparations. Furthermore, high-pressure homogenization is a desirable technology that is employed in the production of topical medications and cosmetics since it is simple to scale up (Leonida & Kumar, 2016). Hot homogenization is done at a high

temperature, and cold homogenization is done below room temperature. Before high pressure homogenization, the active ingredient is dispersed or dissolved in the molten lipid in both procedures. The homogenizer's small gap allows the fluid to be moved by high pressure (100–2000 bar).

Solvent-emulsification evaporation method

Using this method, the drug and the lipids—both liquid and solid—are dissolved in an organic solvent that is water immiscible (cyclohexane, chloroform). An o/w emulsion is created by dispersing the resulting mixture into an aqueous emulsifier solution. Solvent is extracted from the emulsion via low pressure evaporation. Because of lipid precipitation in the aqueous medium, Nanoparticles disperse in the aqueous phase as a result of evaporation. Although there is no heat stress with this approach, Cons of using an organic solvent. Particle size can range from 30 to 100 nm, depending on the surfactant and solid lipid (Iqbal et al., 2012).

Solvent-emulsification diffusion method

The solvent that is saturated with water dissolves the medication and lipids. To create an o/w emulsion, a homogenizer emulsifies a solvent-containing medication and lipids in an aqueous emulsifier solution that is saturated with solvent. Following dilution with excess water (ratio: 1:5–1:10), the lipid nanoparticles precipitate as a result of the organic solvent diffusing from the emulsion droplets into the continuous phase.

Microemulsion method

This process entails dissolving the solid lipid, mixing in the liquid lipid, and then dissolving the drug in the resulting emulsion. Separately, the emulsifier, co-emulsifier, and water are heated to the same temperature. Thermodynamically stable oil in water hot microemulsion is created by slowly stirring the lipid and aqueous phase in the proper ratios (Qidwai et al., 2016).

Double emulsion technique

An aqueous solvent (the inner aqueous phase) is used to dissolve the medication before it is dispersed in the lipid phase to form the primary emulsion (w/o) (the mixture of molten solid lipid, liquid lipid, lipophilic surfactant, and lipophilic active moiety). Maintaining the same temperature for both the lipid and the aqueous phase. Drug loss to the external phase during solvent evaporation is prevented by the stabilizer. Subsequently, the main emulsion is mixed with a significant amount of surfactant aqueous solution and sonicated to create a double emulsion (w/o/w) (Üner, 2006).

Solvent Injection technique

It is a workable new method for producing lipid nanoparticles. This method involves solubilizing lipids in a water-soluble solvent mixture or a water-miscible solvent (such as acetone, methanol, ethanol, or isopropyl alcohol) before quickly injecting the mixture into an aqueous surfactant solution while stirring continuously. The resulting dispersion is filtered to get rid of extra fat (Schubert & Müller-Goymann, 2003).

Micro-fluidization method

The method uses a newly developed, patented mixing technology that makes use of a microfluidizer, a high shear fluid device. During this procedure, the liquid is pushed via

microchannels at a maximum speed of 400 m/s to an impingement location under high operating pressure. Within the "interaction chamber," cavitation together with the resulting shear and impact are responsible for the effective decrease of particle size. The method is applicable to both laboratory and industrial settings (Bodmeier & Huagang, 1990).

Topical therapies for psoriasis

When it comes to topical medicines, patient adherence might be the biggest obstacle to treatment effectiveness. Early patient follow-up, meaning therapy should begin within a week after diagnosis, may help with adherence. There are published recommendations available for the use of topical treatments to treat psoriasis (Alinia et al., 2017).

Humidity and emollients are beneficial and reasonably priced additions to the therapy of psoriasis. The sensations of itching and soreness are reduced when psoriatic skin is kept hydrated and silky. Additionally, maintaining your skin well hydrated will help avoid irritation and the possibility of Koebnerization, which is the development of fresh psoriatic lesions at the locations of trauma.

Even with the advent of more advanced medications, topical corticosteroids continue to be the cornerstone of therapy for topical psoriasis (Samarasekera, Sawyer, Wonderling, Tucker, & Smith, 2013). We still don't completely understand how corticosteroids work in psoriasis. Through their effects on addition to suppressing gene transcription, corticosteroids also have anti-inflammatory and antiproliferative effects.

Topical corticosteroids are used twice a day as part of the standard treatment. With such therapy, most patients will have a quick reduction in inflammation; nevertheless, full skin normalization or a long-lasting remission is not guaranteed. If The patient is using topical corticosteroids and has thick, aggressive lesions. can be sustained. Skin shrinkage with topical corticosteroids is not a concern unless the drug is continued after the skin has recovered to its normal thickness or if portions of the body that are not psoriatic are exposed. Following a clinical improvement, fewer applications should be made (Menter et al., 2011).

Tacalcitol, calcitriol, and calcipotriene (calcipotriol) are used to treat psoriasis are examples of topical vitamin D analogs. A comprehensive evaluation revealed that combination therapy with a topical corticosteroid is more successful than either medication alone, despite the fact that topical vitamin D analogs are beneficial as monotherapy for certain individuals (Mason, Mason, Cork, Dooley, & Hancock, 2013). Lipid based nanoparticles available for treatment of psoriasis as shown in table 1.

Table 1. Lipid-based nanoparticles for the treatment of psoriasis

Sr. No.	Lipid Carrier	Anti-psoriatic agent	Method	Mechanism of action	Route	Reference
1	Solid lipid nanocarriers (SLNs)	Methotrexate	Hot ultrasonication	No toxicity to human fibroblasts or keratinocytes and prolonged drug release in vitro.	Topical	*(Alam, Rizwanullah, Mir, & Amin, 2023)*
		Thymoquinone	Melt-emulsification and ultrasonication	To improve drug solubility, trapping, and penetration, the ethosomal vesicular system may be used as a delivery medium in combination with low skin irritation score and reduced symptoms of erythema, oedema, and thickness in PASI score.	Topical	*(Nordin, Ahmad, Salim, & Yusof, 2021)*
		Triamcinolone acetonide	Emulsification–ultrasonication technique	Drug-loaded SLN was a safe formulation since it showed a sustained drug release profile without systemic transit.	Topical	*(Shetty & Sherje, 2021)*
		Cyclosporine	Microemulsion	Demonstrated systemic absorption, decreased adverse effects, and enhanced concentration in the dermal layers in vitro.	Topical	*(Pradhan et al., 2021)*
		Clobetasol	Microemulsion	The glucocorticoid receptors (GR) are activated by cortisol, which leads to receptor homodimerization and binding to GREs (glucocorticoid-responsive elements)	Topical	*(Jyothi et al., 2021)*

2	Nanostructured lipid carriers (NLCs)	Dithranol	Hot melt homogenization	Reduced the severity of the disease and cytokines such as ILs-17, 22, 23, and TNF-alpha, as measured by the PASI score and the enzyme-linked immunosorbent assay.	Topical	*(Sathe, Saka, Komminen i, Raza, & Khan, 2019)*
		Mometasone furoate	Microemulsion	Superior skin accumulation, reduced main skin irritation score, and total resolution of parakeratosis in vivo	Topical	*(Kaur, Sharma, & Bedi, 2018)*
		Methotrexate	Solvent diffusion	This medication counteracts purine synthesis by inhibiting the generation of dihydrofolate reductase. Additionally, this might cause lymphocyte apoptosis.	Topical	*(Kaur et al., 2018)*
		Capsaicin	Micro emulsion-based method	NLCs show higher skin penetration into deep and hyperproliferative skin in psoriasis cases compared to SLNs, indicating that NLCs would be a far superior option than SLNs for such conditions.	Topical	*(Aneja, Mittal, Dhiman, & Agarwal, 2023)*
		Calcipotriol	emulsification–ultrasonication method	Calcipotriol has significant immunomodulatory properties, reduces keratinocyte proliferation, and stimulates keratinocyte differentiation.	Topical	*(Pradhan et al., 2021)*
3	Liposomes	Psoralen	Cationic liposomes by thin- film hydration method	Skin penetration investigation showed a multiple-fold rise along with decreased levels of psoriatic cytokines and psoriasis plaque symptoms (TNF-alpha, IL-17, and IL-22).	Topical PUVA	*(Pradhan et al., 2021)*

		Cyclosporine	Thin-film hydration	This medication lowers IL-2 levels by blocking the calcineurin manufacturing process.	Topical	*(Nordin et al., 2021)*
4	Nano emulsions	Tacrolimus	Spontaneous emulsification	While psoriasis symptoms improved and blood cytokine levels decreased in vivo, the prolonged-release pattern and skin absorption improved in vitro.	Topical	*(Alam et al., 2023)*
		Curcumin	Low-energy emulsification	Skin penetration increased several times over, and psoriatic activity healed quickly. The HA-ES system's tailored drug administration helps increase curcumin's absorption through the skin.	Topical	*(Xie et al., 2021)*
		Imiquimod and curcumin	Low energy emulsification	Reduced the rate of psoriatic activity and prevented the onset of symptoms similar to psoriasis.	Topical	(Algahtani, Ahmad, Nourein, & Ahmad, 2020)
		Betamethasone dipropionate	Aqueous phase titration method	There have been reports of enhanced anti-inflammatory effectiveness, decreased dose frequency, better penetration, and prolonged drug release for the intended duration.	Topical	(Shetty & Sherje, 2021)
5	Niosomes	Acitretin	Thin-film hydration	Improved drug deposition in HaCaT cells and the ex vivo permeability assay.	Topical	(Agrawal, Petkar, & Sawant, 2010)
		8- Methoxy psoralen	Thin-film hydration method	Enhanced uptake and retention of 8-Methoxypsoralen	Topical	(Iqbal et al., 2012)

6	Transferosomes	Tacrolimus	Rotary evaporation-sonication	Greater skin penetration and mean residence time in vivo when compared to liposomal formulation.	Transdermal	(Nordin et al., 2021)
7	Ethosomes	Anthralin (dithranol)	Thin-film hydration	In clinical investigations, a high penetration rate ex vivo and few side effects following therapy	Topical	(Fathalla, Youssef, & Soliman, 2020)
		Methotrexate and salicylic acid (MTX-SA)	The cold method	PASI score dropped as MTX-release SA's was longer than that of MTX alone.	Topical	(Chandra, Aggarwal, Manchanda, & Narula, 2019)

New Era of Psoriasis Treatment

Lipid-based NPs in psoriasis treatment have been thoroughly investigated. These consist of liposomes, transfersomes, ethosomes, niosomes, solid lipid nanoparticles (SLNs), and nanostructured lipid carriers (NLCs). Since lipid-based NPs are flexible and can penetrate the extracellular matrix in the stratum corneum layer of the skin, they are useful for transdermal medication administration. For example, NLCs containing anti-psoriatic medications such as methotrexate have demonstrated encouraging outcomes in terms of improving drug penetration and therapeutic outcomes.

Drug delivery for psoriasis has also been investigated using metallic nanoparticles, such as gold and silver nanoparticles. The size and surface properties of these inflexible nanocarriers may be adjusted. For example, functionalized gold nanoparticles have shown enhanced medication delivery and immunomodulatory effects in skin psoriasis (Bessar et al., 2016; Crisan et al., 2018).

Numerous studies have been conducted on polymeric nanoparticles, such as chitosan and poly (lactide-co-glycolic acid) (PLGA) nanoparticles. NPs made of synthetic polymers have specific properties for the encapsulation and release of drugs. Curcumin-loaded PLGA NPs have demonstrated better therapeutic outcomes and increased medication penetration into psoriatic skin (Gomez et al., 2019). Nanofibers, created by electrospinning and other techniques, have become interest as potential means of administering medication to treat psoriasis. Anti-psoriatic medications have been loaded into these nanofiber-based delivery devices for regulated release and improved therapeutic effectiveness (Kumar, Verma, Joshi, Utreja, & Sharma, 2021).

Optimizing the therapy of psoriasis requires the identification and confirmation of trustworthy biomarkers. Biomarkers can direct therapeutic decisions, help diagnose diseases, and predict how well a treatment will work. To enable more individualized and efficient treatment plans, ongoing research focuses on finding biomarkers linked to disease activity, therapy response, and the emergence of comorbidities.

Available treatment of psoriasis

Currently, there isn't a perfect medication to completely treat psoriasis. The current treatment option's main goals are to lessen the patient's symptoms, stop the condition from becoming worse, and enhance their quality of life. For the treatment of psoriasis, calcineurin inhibitors, retinoids, keratolytic drugs, vitamin D3 analogs, corticosteroids, and biologics are available.

Several technologies have been developed recently to improve topical medication therapy's effectiveness and safety. Additionally, novel drug carriers provide a chance to include novel compounds into the treatment of topical psoriasis. Vesicular drug delivery techniques, such as liposomes, transferosomes, niosomes, and proniosomes, as well as nonvesicular drug delivery systems, such foams, gels, and nanoparticles, have been created for these goals.

The primary goal of the psoriasis treatments available today is to relieve symptoms. The three primary treatment modalities are phototherapy, systemic therapy, and topical therapy. Typically, topical treatment is applied to mild cases of psoriasis, and if that doesn't work, phototherapy is

used. Systemic therapy is used to treat moderate to severe cases of psoriasis. There is currently no medication that can completely eradicate psoriasis.

Future perspectives

The latest developments in the administration of anti-psoriatic medications using NLCs have been highlighted in the current review. We see this innovative medication delivery method as the greatest option going forward for treating psoriasis because of its many benefits over first-generation systems. Lipid-based carriers are thought to have a new path thanks to this delivery method. However, not sufficient clinical research has been carried out to guarantee the therapeutic potential of novel NLCs in psoriasis, despite significant efforts in preclinical research and NLC synthesis. This underscores the need more safety and clinical studies in this field. The possibility of any unforeseen health risks resulting from these nanoparticles is the sole issue that remains regarding the commercial destiny of these NLCs for anti-psoriatic treatment.

Furthermore, it is anticipated that in the future, several regulatory bodies, including the FDA, MHRA, CDSCO, and others, would cooperate to develop comprehensive and strict rules for the manufacturing and management of nano-formulations.

Conclusion

In conclusion, the treatment landscape for psoriasis has witnessed a transformative shift, particularly with the emergence of innovative drug delivery systems, such as Nanostructured Lipid Carriers (NLCs). These lipid-based nanocarriers offer distinct advantages, including increased drug loading capacity, regulated drug release timelines, extended shelf life, and sensory masking. NLCs have demonstrated promising outcomes in the topical administration of anti-psoriatic agents, showcasing potential for enhanced drug penetration and therapeutic efficacy. However, there is a need for further clinical studies to validate the therapeutic potential of NLCs in psoriasis treatment and assess any potential health risks associated with their use. As the field progresses, collaboration among regulatory bodies is essential to establish comprehensive guidelines for the manufacturing and management of nano-formulations, ensuring their safety and efficacy in clinical applications. The ongoing exploration of diverse nanocarriers and evolving treatment modalities reflects a promising future for personalized and efficient psoriasis management.

Conflict of Interests:

None

Data Availability Statement:

All the data were presented in the present article.

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