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Solid Lipid Nanoparticles as an Efficient Delivery System for Natural Skin Care Cosmetics: A Review

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ABSTRACT

Background: Natural skin care products, as health & beauty products, have formulations derived from natural active ingredients. Cosmetic actives have been incorporated into their novel formulations such as sunscreens and anti-aging products, but the challenges associated with their low solubility, low penetration, and physicochemical instability upon dermal application remain unresolved. To overcome these limitations, one method is to use lipid-based carriers, which have been recognized for their crucial role in enhancing their low solubility, increasing skin permeation, and enhancing steadiness. This review study focuses on current advancements in skin care formulations that employ a new nanotechnology-based system consisting of solid lipid nanoparticles (SLNs).

Materials and Methods: In this review, we mentioned some experiments that have investigated the dermal applications of some natural products incorporated in SLNs formulation and discussed moisturizing, wound healing, sun protection, whitening and anti-tyrosinase, anti-aging and anti-acne activities.

Conclusion: The nanoparticles such as SLNs are used to effectively deliver cosmeceuticals and enhance the efficiency of skin care products.

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Introduction

The skin acts as a primary barrier that protects the body from free radicals. A variety of free radicals are produced by exposure to UV radiation, dusts, chemicals, and air pollution [1]. Free radicals cause significant harm to the skin, including the damage to the skin's elasticity and collagen production, leading to the development of wrinkles and reduced elasticity of the skin. Additionally, it can disrupt the distribution of melanocytes and melanin, resulting in pigmentation and potential skin cancer [2]. According to Rodan et al., the most important desire in humans is to achieve "perfect skin," which is perceived as a necessity for health [3]. Consequently, individuals from all age groups constantly search for the best skincare products.

A youthful or flawless skin can be achieved based on dermal and epidermal characteristics, including the quality and density of extracellular environment and the provision of cells to the connective tissue. Therefore, the skin structure can be predicted based on various skin conditions, such as acne, photoaging, unusual pigmentation, and dryness [4]. The cosmetic skincare products can play an important role in restoring skin's perfectness and health [5]. The presence of natural components in these products can improve skin quality [6]. To meet the demands of a large number of consumers and increase the effectiveness of cosmetic skincare products, it is important to differentiate between active therapeutic ingredients for the topical administration of cosmetics [7].

In recent decades, there has been a notable increase in the use of nanomaterial products in different sectors, including cosmetics industry, pharmaceutical industry, and skincare products market. In the field of cosmetics, nanomaterials have been extensively used for the preparation of conditioners, hair serums, moisturizing creams, hair-repairing shampoos, skin-whitening creams, and anti-wrinkle creams [8]. Cosmeceuticals, as cosmetic products containing naturally active ingredients with medicinal features, have been employed due to their ability to improve appearance [9]. These products have shown medicinal effects on the skin, thereby are used to effectively treat various disease symptoms. Nano-cosmeceuticals provide improved biocompatibility and stability, long-lasting effects, and the potential to enhance the distribution of active materials on the skin. Various types of nanomaterials, including niosomes, liposomes, nanostructured lipid carriers (NLC), solid lipid nanoparticles (SLN), gold nanoparticles, nanoemulsions, and polymeric nanoparticles, have been recommended for application in topical products due to their biocompatible nature [10, 11]. Their use in personal care products allows for better control over the distribution of beneficial cosmeceuticals by creating a thin film, ensuring more accurate delivery to the skin.

Skin aging is a multifaceted process that can be manifested externally and internally [12]. Approximately 90% of skin aging is attributed to exposure to UV radiation. Lifestyle-related factors such as alcohol consumption, smoking, inadequate sleep, environmental factors such as pollution, and poor nutrition also play a role in accelerating the skin aging process. The initial signs of skin aging include dryness, wrinkle formation, and reduced skin elasticity. Fortunately, these first symptoms can be prevented or delayed. While traditional topical formulations such as suspensions, solutions, gels, aerosols, powders, and emulsions are commonly used for delivering active ingredients, they have limitations that may affect treatment safety and effectiveness. To address these challenges, various nanomaterials have been developed for delivering active ingredients. The ongoing preparation of skincare products using active ingredients that employ nanomaterials in health and cosmetic sectors, presents promising opportunities with positive impacts on society and industries [13].

The application of drugs topically on the skin is associated with the lowest level of permeation. As a result, the concentrations of drugs are increasing at their sites, namely the epidermis and dermis. This increase leads to a noticeable decrease in systemic absorption, thereby reducing the occurrence of subsequent side effects [14-16]. However, there are restrictions to the penetration of drugs into the skin as a result of packed lipophilic character of the stratum corneum (SC). To overcome these limitations, biodegradable and low cytotoxicity carrier systems such as SLNs are commonly used in topical formulations. SLN carriers are capable of loading hydrophilic drugs, are cost-effective, and can be easily prepared [17]. Moreover, the use of SLNs can enhance the stability of active pharmaceutical ingredients [18, 19]. SLNs can produce an adhesive film on the skin, which is beneficial. Furthermore, SLNs formulations have occlusive effects that reduce transepidermal water loss and increase the SC hydration. Nanocarriers can bind to the SC, and their efficacy is greatly influenced by nanoparticle size. This attachment to the SC can improve drug permeation by widening the cavities between corneocytes and reducing their packing [20]. These nanocarriers are crucial for the stability of applied drugs [14]. Table 1 indicates some marketed SLNs formulations.

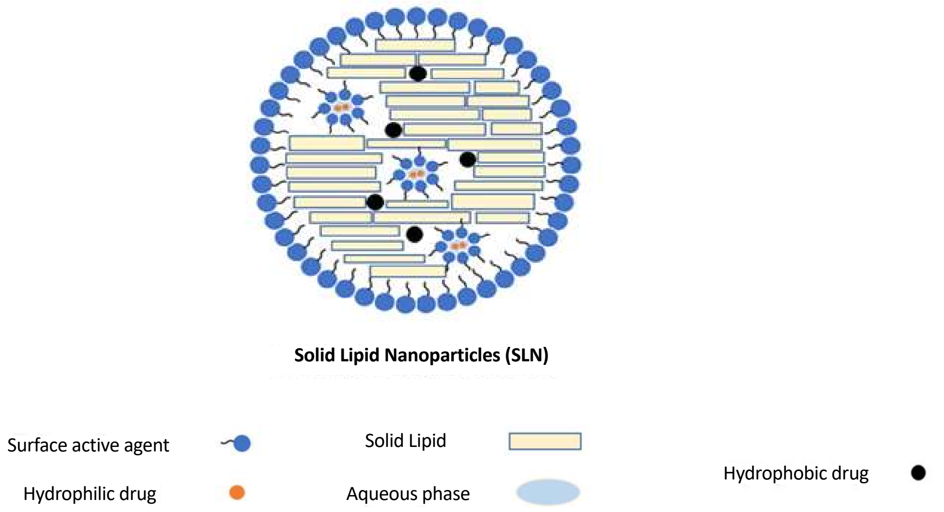

Figure 1. Schematic representation of SLNs containing lipophilic and hydrophilic drugs [29]

The primary focus of this work revolves around presenting a concise overview of solid lipid nanoparticles (SLNs) for the purpose of skin care applications, highlighting their advancements in treating various medical conditions.

SLNs

The SLNs are colloidal drug delivery systems with a size of 10-1000 nm, acting as viable substitutes to other colloidal systems, including liposomes, emulsions, and polymeric nanoparticles [21]. The reproducible preparation of SLNs can be achieved in the absence of toxic organic solvents [22]. The solid matrices of SLNs play a significant role in enhancing the stability of active components [23]. SLNs are known as safe carriers due to their production from biodegradable lipids (e.g. triglycerides, partial glycerides, waxes, steroids, and fatty acids) and other resources normally accepted as nontoxic [24]. The ability to entrap hydrophilic and lipophilic medicines with advanced efficacies compared to liposomes, to cause controlled drug release, and to be coated with appropriate ligands for targeting specific tissues, has made SLNs applicable at various administration modes [25]. SLNs, as the first generation of lipid nanoparticles with a solid matrix, were initially developed in the mid-1990s and have become a considerable research interest due to their unique advantages [26]. Similar to liposomes and nanoemulsions, SLNs consist of physiologically biocompatible excipients and their solid matrices, similar to polymeric nanoparticles, can effectively protect loaded drugs [27]. Due to the presence of similar lipid molecules, the matrices of SLNs are perfect crystals and can be compared to a well-constructed wall of bricks (Figure 1). Consequently, any high-energy modifications within the SLNs matrices causes transition towards a more ideal state, minimizing imperfections and expels drugs [28].

SLNs have some limitations; their high degree of crystallinity leads to reduced drug entrapment and the risk of drug expel caused by crystallization under storage conditions. Moreover, an initial burst release commonly happens with these formulations. Within SLN matrices, drug molecules are within the fatty acid chains or glycerides. As solid lipid structures undergo polymorphic alterations and during the storage period, there is a tendency for the release of previously dissolved drugs in SLNs [30].

Dermal applications of cosmetics with SLNs

Moisturizing

The SC contains approximately 10–20% water. When there is an increase in the skin water loss, causing the humidity to drop below this level, the protecting layer of the SC may be damaged. In this case, it is necessary to apply topical formulations with occlusive properties onto the SC to replace the water content. Therefore, the SC initiates its self-repair mechanism. By occlusion, the evaporation of water from the skin is reduced, allowing the water to be retained within the skin. As a result, the SC undergoes swelling, leading to an enhanced penetration of medications [33]. SLNs has the ability to produce a protective film that avoids water loss through evaporation. This film also improves skin hydration and enhance the overall appearance of the skin, especially in cases of eczema. Due to small size, SLNs offer superior occlusion compared to macroemulsions [33, 34].

Table 1. Examples of marketed SLNs for dermal administration [31, 32]

No.	Product Name	Company	Effect
1	Allure Body Lotion	Chanel	Anti-wrinkle, skin brightening, moisturizer
2	Allure Perfume	Chanel	Fragrance
3	Allure Eau de Perfume Spray	Chanel	Fragrance
4	Phyto NLC Active Cell Repair	Sireh Emas	Skin firming, skin hydration, and reduction of tan
5	Soosion Facial Lifting Cream SLN Technology	Soosion	Antiwrinkle cream
6	Youthful Face Contour Cream	Sany Skincare	Anti-wrinkle, skin firming
7	Nanobase	Yamanouchi Pharma	Long lasting conditioner for skin dryness

Many studies have been conducted on the occlusive effects of SLN and NLC formulations, which involves the formation of a film on the skin, resulting in water evaporation. Notably, studies have demonstrated that SLNs have a greater occlusive effect compared to NLC matrices with the same lipid content [35]. Barua et al. examined the moisturizing effect of serine SLNs and polysaccharide-rich reed (*Phragmites communis*) root extract (RRE) used in hydrogel bases. Application of hydrogels with serine-SLNs and/or RRE on the volar forearm of healthy volunteers was conducted carefully. Assessment of their moisturizing efficiency was done by monitoring conductance values utilizing a skin surface hygrometer. The calculation of the area under the normalized conductance-time curve (AUCC) was conducted and compared as an indicator for the skin's water holding capacity. Based on the results, hydrogels with serine-SLN did not show a significant moisturizing effect, while the hydrogel with 0.25% RRE demonstrated a significant increase in skin's moisture content. Nevertheless, the use of more than 0.25% RRE in the hydrogel base led to a decrease in moisturizing efficacy because of a viscosity reduction. A significantly improved moisturizing effect was reported in the hydrogel with 0.25% RRE and 3% serine-SLN, with the AUCC showing a 2.21-fold increase compared to the control (blank) hydrogel. These findings suggest the potential for effective serine delivery to the skin through lipid-based nanocarriers and RRE, offering a promising approach for efficient skin moisturizing [36].

Wound healing

Chamomile oil (CM) plays a critical role in enhancing wound healing; however, its poor ability to penetrate into tissue and degradation limits its topical application. Gad et al. reported a new SLN formulation by adding for wound healing activity. The SLNs were synthesized using a hot homogenization technique utilizing 20%w/w stearic acid and CM. Fourteen rats were divided into 5 groups for in vivo study. Group I was the normal control, group II consisted of wounded rats without any treatment, and Groups III to V consisted of wounded rats treated with blank SLNs, CM cream (Camisan®), and CM-SLNs, respectively. The CM loaded SLNs showed particles with irregular shapes, with an outer chamomile oil shell covering the lipid core. The optimized CM-SLNs, consisting of stearic acid and CM in a 7:3 ratio, showed a particle size of 542.1±27.51 nm and a zeta potential of -35.9±0.602 mV with appropriate viscosity and occlusive activities. Topical application of CM-SLNs demonstrated improvements in restoring the normal integument structure, wound contraction, transforming growth factor-β1 and collagen deposition, as well as a reduction in the Interleulin-1β and metalloproteinases-9/tissue inhibitor metalloproteinase-1 ratio in comparison with the other groups. In conclusion, the addition of CM to SLNs has an important effect on enhancing the wound healing activity [37].

Saporito et al. developed a synthesis of SLNs and NLCs with eucalyptus or rosemary essential oils to facilitate the healing of skin wounds. The lipid nanoparticles included natural lipids such as cocoa butter (as a solid lipid) and olive oil or sesame oil (as liquid lipids). Lecithin, a surfactant, was selected to stabilize the nanoparticles and prevent their aggregation. The preparation of the systems involved high shear homogenization followed by ultrasound application. The nanoparticles were assessed in terms of physical-chemical properties, bioadhesion, biocompatibility, in vitro proliferation improvement, and wound healing activities compared to normal human dermal fibroblasts. The in vivo results demonstrated the ability of NLCs to improve the healing process. Notably, the use of olive oil, having a high level of oleic acid, with eucalyptus oil showed a synergistic effect regarding the antimicrobial activity and promotion of wound repair [38].

Sun protection

The use of herbal formulations for sunscreen preparations arose from this assumption that the synthetic chemicals and organic compounds are absorbed into the bloodstream by application on the skin. This led researchers and skincare experts to investigate herbal and natural ingredients as potential alternatives for sunscreen formulations, aiming for products that are safer and less toxic [39].

SLNs have inherent characteristics of physical UV-blockers, suggesting the potential of producing a more efficient sunscreen system with lower adverse effects. In this regard, Wissing & Müller proposed that, by incorporating the chemical sunscreen tocopherol acetate into SLNs, chemical degradation can be prevented, and the UV-blocking capacity can be enhanced. Aqueous SLNs were prepared and used into gels, followed by assessments of particle size, stability during storage, and thermoanalytical properties. They used various in vitro techniques to investigate the UV-blocking capacity of the SLNs, and showed that they were at least two times more efficient than their control emulsions with the same lipid content. Interestingly, placebo SLNs even exhibited better UV-blocking efficacy than emulsions having tocopherol acetate as a molecular sunscreen. The incorporation of tocopherol acetate into SLNs resulted in an additive UV-blocking effect. They also examined the film formation of SLNs on the skin and their occlusive properties. The results indicated that the incorporation of tocopherol acetate into SLNs led to an enhanced sunscreen and skincare formulation [40].

A study prepared the synthesis of SLNs and silymarin, incorporated to a sunscreen cream to determine the sun protection factor (SPF) of the cream. The SLNs were prepared using the micro-emulsion method, with glyceryl monostearate as lipid and Tween 80 as an emulsifier. Various parameters including drug encapsulation, particle size and morphology, zeta potential, and polydispersity index were assessed. The dispersion was then incorporated into a sunscreen cream and assessed for permeation, viscosity, spreadability, in vitro and in vivo SPF determination, and in vivo skin irritation. Findings indicated that the increase in the concentration of emulsifier resulted in higher entrapment efficiency of silymarin. The in-vitro and in-vivo SPF had values of 13.80 and 14.1, respectively. Their stability studies conducted under accelerated conditions, did not reveal any significant changes in the parameters. Therefore, they concluded that the sunscreen containing silymarin SLNs have better photoprotective property [41].

Khameneh et al. prepared some SLNs using glyceryl monostearate, Tween 80, and varying amounts of safranal by employing high shear homogenization, ultrasound, and high-pressure homogenization (HPH) methods. The SLN formulations were assessed in terms of size, zeta potential, morphology, thermogravimetry, and drug loading. The SPF was determined in vitro using transpore tape. The moisturizing properties were also appraised. It was observed that the SPF of SLNs-safranal formulations increased with the increase in the amount of safranal. The mean size of particles was approximately 106 nm using probe sonication and 233 nm using the HPH method. The drug loading of safranal was about 70% for all SLNs-safranal formulations. They concluded that the SLNs-safranal formulations are effective for topical administration of safranal and can successfully provide appropriate sunscreen properties [39].

Rodrigues et al. prepared an Aloe vera-loaded SLNs sunscreen cream using the microemulsification technique, and evaluated its photoprotective capabilities. The in vitro SPF was found to be 16.9±2.44, while the in vivo SPF was approximately 14.81±3.81. Stability tests under accelerated conditions indicated no significant alterations in the study parameters. The incorporation of Aloe vera SLNs into the cream resulted in a sunscreen cream with an SPF comparable to existing sunscreens in the market [42]. In another study, spinach (*Spinacia oleracea*)-loaded SLNs were assessed for the photoprotective efficacy of a sunscreen cream. Solvent emulsification technique was employed to prepare the spinach-loaded SLNs, followed by a series of characterization tests on the developed SLNs. The optimized formulation was incorporated into a cream and evaluated for its photoprotective properties. The sunscreen cream exhibited acceptable viscosity, spreadability, extrudability, and release rate. The in-vitro and in-vivo SPF of the formulation were 15.9 and 14.75, respectively, indicating the good photoprotective effect. Accelerated stability tests showed no significant changes in the study parameters. This study highlights the potential use of spinach-loaded SLNs as a photoprotective agent in sunscreen formulations [43].

Skin whitening and anti-tyrosinase activity

The addition of chemically stable active ingredients into the SLN matrix can provide protection against decomposition. Dingler et al. synthesized vitamin E loaded-SLNs using high-pressure homogenization. These SLNs exhibit physical stability in aqueous dispersions and maintain their stability even after being integrated into a topical cream, confirmed using photon correlation spectroscopy and differential scanning calorimetry. The ultrafine particles formed an adhesive film on the skin, resulting in an occlusive effect. This occlusion enhances the penetration of active ingredients, such as vitamin E, into the skin, proved by stripping tests. In addition to chemical stabilization and occlusion effects, SLNs also showed a pigment effect that helps cover undesired colors, thereby improving aesthetic acceptance among customers [44]. Therefore, SLNs not only protect active ingredients from degradation and enhance their penetration into the skin, but also provide occlusive and aesthetic effects, making them versatile and promising carriers for skincare formulations.

SLNs containing lycopene were prepared and their anti-tyrosinase properties were investigated by Shahraki et al. The formulation was examined in terms of drug release and anti-tyrosinase ability. The determination of encapsulation efficiency was carried out directly. The rate of drug release was evaluated using the cell diffusion method. They employed cytotoxicity tests, cellular tyrosinase inhibition, melanin content, and free radical level measurements to assess the impact of the formulations on melanogenesis inhibition. The western blot assay was also employed to determine the levels of tyrosinase and Microphthalmia-associated transcription factor. The particle size for lycopene-SLNs yielded was 151.1±2.3 and the nanoparticles had a spherical shape. The encapsulation efficiency was 85.76±2.75%. In assessing the anti-tyrosinase effects of lycopene-SLNs, a significant decrease in cellular tyrosinase activity, melanin, and ROS levels was observed. Moreover, lycopene-SLNs reduced melanin production with minimal toxicity against melanoma cells [45].

Anti-aging activity

Polyphenols are known as dietary antioxidants. They have recently received significant attention for their potential in preventing skin aging and hyperpigmentation caused by UV-irradiation. *Prunus persica* L. leaves, as by-products, have considerable antioxidant activity due to their high polyphenol content. Mostafa et al. developed a cosmeceutical cream for anti-aging skin care and skin whitening by utilizing the ethanolic extract of *P. persica* L. leaves (PPEE) loaded into SLNs to improve the skin delivery. The chemical analysis of PPEE demonstrated a remarkably high content of total phenolics and flavonoids, as well as notable antioxidant properties. Additionally, a unique acylated kaempferol glycoside was successfully isolated and its structure was fully elucidated. In vitro cytotoxicity studies carried out on a human keratinocytes cell line indicated the non-toxicity of PPEE and PPEE-SLNs. These compounds also showed significant anti-elastase activity. In addition, PPEE-SLNs and kaempferol displayed significantly higher anti-collagenase and anti-tyrosinase activities compared to EDTA and kojic acid, respectively. Various formulations of PPEE-SLNs cream (2% and 5%) were evaluated for their potential anti-wrinkle activity against UV-induced photoaging in a mouse model using a wrinkle scoring method. The results showed the highly significant protective effect of formulations against UV, as evidenced by tissue biomarkers and histopathological studies [46].

Plianbangchang et al. assessed the efficacy of curcuminoids loaded SLN facial cream as an anti-aging agent in 33 healthy volunteers with noticeable facial wrinkles. They applied the prepared formulation on one half of their face for eight weeks before going to bed, while the other half of the face was considered as the control side. The primary measures were skin wrinkle, hydration, melanin content, biological elasticity, and viscoelasticity. To assess skin irritation, the transepidermal water loss index, skin pH, and observations from physicians were used. Their findings showed that from the third week onward, all measures of the treated side were significantly better than those of the control side. Furthermore, all measures showed significant improvement compared to the baseline by two weeks. No skin irritation was observed. It was concluded that curcuminoids loaded SLN cream is a successful anti-aging preparation with an acceptable safety [47].

Anti-acne activity

The etiology of acne is multifactorial, involving four primary factors, including excess sebum release, colonization by *Cutibacterium acnes* (*Propionibacterium acnes*), follicular hyperkeratinization, and skin inflammation. There are standard acne therapies based on the intensity of the condition. As a first-line approach for mild to moderate acne vulgaris, topical medications containing synthetic formulations or a combination thereof with oral antibiotics are used. However, the majority of these topical medications have side effects such as skin irritation, water loss, scaling, and pruritus. Therefore, the exploration of phytochemicals as an alternative therapy to mitigate the unfavorable side effects of synthetic compounds has been investigated [48].

The stable and colorless hydrogenated product of curcumin, known as tetrahydrocurcumin (THC) or white curcumin, has remarkable antioxidant and anti-inflammatory properties. In a study, Kakkar et al. aimed to enhance the topical bioavailability of THC by incorporating it into a nano-carrier system and formulating it as a hydrogel using a microemulsification technique to prepare lipid nanoparticles of THC (THC-SLNs) with a mean particle size of 96.6 nm and a zeta potential of -22 mV. Ex vivo permeation studies demonstrated that the THC-SLNs gel had approximately 17 times higher skin permeation compared to the free THC gel. Furthermore, their studies indicated that the formulated THC-SLNs gel was nonirritating and stable with acceptable occlusivity. Pharmacodynamic test in an excision wound mice model revealed the enhanced anti-inflammatory activity of the THC-SLNs gel, which was further confirmed through biochemical and histopathological studies. Importantly, the THC-SLNs gel exhibited significantly better activity ($P\leq0.001$) compared to the free THC gel. Given that inflammation is inherent to various skin disorders, this prepared product can open up new therapeutic possibilities for different skin problems [49].

Garg et al. prepared carbopol hydrogels with eugenol-loaded SLNs (EG–SLNs) to target the epidermis for treating fungal infections in the skin by measuring the amount of eugenol present in the epidermis of human cadaver skin. Moreover, they conducted an occlusion study to investigate the mechanism behind the epidermal targeting of the EG–SLN hydrogels. The particle size and morphology of the EG–SLNs remained unchanged after being incorporated into the hydrogel. The EG–SLNs hydrogel with stearic acid and Compritol reported a significantly higher accumulation of eugenol in the epidermis compared to the hydrogel containing eugenol–hydroxypropyl-β–cyclodextrin complex and the almond oil solution of eugenol. The occlusion study demonstrated higher hydration of human skin treated with the EG–SLN hydrogel compared to both the hydrogel and intact skin. Therefore, hydrogels containing EG–SLNs have the potential for epidermal targeting and treating fungal infections in skin [50].

Isotretinoin (ITR) is the preferred medication for treating all forms of acne, including persistent, severe, and nodulocystic acnes. The most commonly used administration method for this medication is the oral method, but it has been reported to have severe side effects such as teratogenicity, skin dryness, and psychological disorders. Although topical delivery is recommended for ITR, it is associated with challenges such as skin irritation, redness, and skin peeling. Kaisar et al. prepared “optimized” SLNs of ITR and evaluated their ability to be applied on the skin, to transport the medication, and to treat acne in male Laca mice induced by testosterone. The SLNs were able to effectively transport the drug to different layers of the skin and created drug micro-reservoirs. These nano-colloidal systems exhibited significant potential in treating acne and were well-tolerated by the mouse skin. The results suggested the great promise of the optimized SLNs of ITR in reducing skin irritation and improving therapeutic efficacy [51].

Korkmaz et al. prepared coenzyme Q10 loaded SLNs using the high-speed homogenization method, which were then incorporated into Carbopol 974P hydrogels. Compritol 888 ATO was used as the lipid base, while Poloxamer 188 and Tween 80 were used as surfactant and co-surfactant, respectively. The optimized particle size for both blank and Q10-loaded SLNs was 152.2 nm and 142.4 nm, respectively, with a low size distribution. The loaded SLNs showed a negative charge of -13.7±1.3 mV, and the encapsulation efficiency of Q10 was 89%, with a production yield of 94%. Trolox equivalent antioxidant capacity analysis demonstrated that the antioxidant potential of Q10 could be preserved in SLNs. Furthermore, diffusion studies on rat abdominal skin revealed that the delivery of Q10 was doubled in SLN incorporating gels, with an approximate delivery of 40 $\mu g.cm^{-2}$, compared to gels without SLN. This suggests that Q10-SLN loaded gels can be effective delivery systems for proper carrying of Q10 into the skin while maintaining its antioxidant properties [52]. This highlights their potential as advanced skincare formulations with enhanced aesthetic appeal.

Conclusion

Natural products have long been used for producing cosmetic products, due to their nutritional and medicinal importance with low or no adverse effects. They also can be used for the preparation of medicines. The conventional personal care products often contain potentially toxic chemicals that not only put the human health at risk but also harm the environment. Natural skincare products include topical creams, lotions, and serums composed of ingredients derived from nature. They can reduce the risk of skin irritation, allergies, and diseases. There are numerous plants that can be used in cosmetics industry.

This research focused on exploring cosmetic delivery systems. Nanotechnology can be efficiently employed to improve the safety, efficacy, stability, and aesthetic appeal of the cosmetic skincare products, which can eventually lead to increased customer satisfaction. It is crucial to handle and manufacture nanoproducts while taking into account the safety of consumers and the environment. However, their use in cosmetics industry should not be overstated and more studies in the future are needed.

SLNs, as the latest advancement in lipid-based nanosystems, have recently received great attention as promising drug delivery systems for a diverse range of chemical compounds, including natural substances. SLNs offer advantages such as enhanced stability and efficacy, controlled and sustained drug release. They are biocompatible and eco-friendly, making them suitable for applications targeting the stratum corneum of the skin.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors contribution's

Conceptualization, study design, data collection, review, editing and final approval: All authors; Writing the original draft: Omolbanin Shahraki; Project administration: Sara Daneshmand.

Conflict of interest

The authors declared no conflict of interest.

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