REVIEW ARTICLE

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Nanotechnological Applications in Dermocosmetics

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ABSTRACT

***Objective*: Identify the types of nanoparticles used in dermocosmetics and their main applications.**

***Methods*: A bibliographic review was carried out in the databases Google Scholar, and PubMed, as well as databases subscribed to the system of libraries, documents, and information of the Universidad de Costa Rica such as ScienceDirect, Elsevier, EBSCO, MEDLINE, Clinical-Key, among others. The search was conducted in both English and Spanish.**

***Conclusion*: Nanotechnology in the cosmetic industry has been an area that has grown exponentially in recent years. Various types of nanoparticles are used in different skincare applications in the cosmetics industry; however, much research remains to be done on the safety and toxicity of their use for humans and the environment.**

Keywords: Dermocosmetics, nanocosmetics, nanoparticles, nanotechnology, skin.

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I. Introduction

A substance or combination of substances designed to be applied to the exterior surfaces of the human body is known as a cosmetic product (epidermis, hair, nails, lips, external genitalia). They can also be used to clean, perfume, protect, change the appearance of, maintain the health of, or enhance the scents emerging from the mouth's mucous membranes and teeth. Skincare items are those that are applied to the epidermis. The formulation's technology and constituent composition both affect how successful they are. Various packaging options for skincare products are available, including liquids (solutions or suspensions), solids (powders), and semisolids (gels and emulsions). Emulsions are the most common and can be categorized based on whether they are in the form of creams or lotions [1], [2].

One of the most exciting areas of the twenty-first century is nanotechnology. By observing, measuring, manipulating, regulating, and manufacturing materials at the nanoscale, it can turn the theory of nanoscience into practical applications. Nanotechnology is described as "a science, engineering, and technology that is carried out at the nanoscale (1 to 100 nm), where unique phenomena have enabled new applications in a wide range of fields, such as chemistry, physics, biology, medicine, engineering, and electronics" by the United States National Nanotechnology Initiative (NNI) [3].

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Nanomaterials are now employed to a greater extent in the manufacture of athletic gear, tires, catalysts, electronic components, food, sunscreens, cosmetics, antibacterial, and antifungal medicines. These materials are anticipated to be used more and more in medical imaging, drug administration, and illness diagnostics [4]. Nano-sized components, such as nanoemulsions, nanocapsules, nanosomes, niosomes, or liposomes, which are microscopic vesicles (50–5000 nm) made up of conventional cosmetic ingredients, are frequently found in most modern cosmetics. Individual particles having a diameter of less than 100 nm are considered nanoparticles, while their aggregates may be more significant [5], [6].

The cosmetics sector is highly interested in nanoparticles used for medicine delivery. Nanoemulsions, nanocrystals, liposomes, niosomes, micelles, polymeric nanocapsules, solid lipid nanoparticles, nanostructured lipid carriers, carbon nanotubes, and dendrimers are a few examples of vesicular release mechanisms employed in nanoencapsulation [7], [8].

The main benefits of using these nanoparticles in cosmeceuticals are improved stability of cosmetic ingredients (like some vitamins, unsaturated fatty acids, and antioxidants), effective protection of the skin against harmful UV rays, creation of aesthetically pleasing products (for example, the use of smaller particles of active mineral in mineral sunscreens allows them to be applied without leaving a perceptible white dye) and targeting of the active ingredient at the skin's surface. [9], [10].

II. Methods

Several databases, including Google Scholar, PubMed, and databases subscribed to the system of libraries, documents, and information of the Universidad de Costa Rica, including ScienceDirect, Elsevier, EBSCO, MEDLINE, and Clinical-Key, among others, were consulted as part of a bibliographic review of various sources of information. The years 2015 to 2021 were covered by searches using the keywords nanotechnology, nanoparticles, dermocosmetics, skin, skincare, and nanocosmetics.

III. Discussion

A. Some Types of Nanoparticles used in the Cosmetic Industry

Liposomes are spherical vesicles made of various lipids and phospholipids, primarily phosphatidylcholine. Liposomes can be as small as 25 nm or as large as microns. Typically, they are created in an aqueous environment with the proper balance of lipids to water and thermal energy from cholesterol and natural phospholipids. Both hydrophilic and hydrophobic chemicals can be used with them. They are employed in the cosmetic sector since they are non-toxic and biodegradable. When distributed in water, several antioxidants, including carotenoids, CoQ_{10}, lycopene, and other active ingredients like vitamins A, E, and K, bond in liposomes, increasing their power both physically and chemically. It is advantageous to utilize phosphatidylcholine in skin and hair care products like moisturizers and shampoos since it possesses conditioning and softening characteristics [6].

Ultrasomes, the advanced lipid particle type that makes up ultrasomes functions as a cross between lipid nanoparticles and oil-in-water (o/w) emulsions [11]. An encapsulated Micrococcus luteus endonuclease is used to create liposomes. By including this enzyme, the damaging effects of UV radiation on the DNA of the skin can be eliminated, lowering the chance of skin cancer. By preventing the expression of pro-inflammatory cytokines including tumor necrosis factor (TNF) and interleukins-1 (IL-1), IL-6, and IL-8, it also serves as an immune system defender. These specific liposomes combat wrinkles, sagging skin, and loss of tone and elasticity by repairing cells [12].

Photosomes, some sunscreen products use photosomes, a form of liposome that releases a photo-reactivating enzyme from the marine plant Anacystis nidulans, to protect skin exposed to the sun. By encapsulating a light-activated enzyme (photolyase) in a liposome, photosomes in light activation reverse cellular DNA damage, lowering immune suppression and cancer induction, and aid in DNA damage repair [13], [14].

Nanocrystals, pure drug particles in the nanometer range are referred to as drug nanocrystals. These particles are stabilized by a surfactant, occasionally by a little quantity of polymer, or by a combination of these. This submicron dispersion typically ranges in size from 100 nm to 1 m. Due to an increase in surface area that is made available when particle size is reduced as well as an improvement in particle curvature that increases dissolution pressure, an increase in saturation solubility is seen. In comparison to macrocrystals, nanocrystals offer numerous advantages at sites of contact with the skin or mucosal surface because of the increase in surface area. Not to mention the enhanced adherence of the nanocrystals to the skin surfaces, extending their time in contact with the surface. In addition, tiny particles can enter cells through the intercellular and follicular channels considerably more quickly than macroparticles can [15].

Solid lipid nanoparticles (SLN), at both body and room temperature, SLNs are a kind of colloidal particles made of solid lipids. Since the drug is significantly less mobile in a solid lipid matrix than it is in a liquid oil, using solid lipids rather than liquid oils can result in a controlled release of the drug. The average diameter of SLNs is between 50 and 1000 nm, and they are made up of lipids that are tolerated by the body that are spread in an aqueous surfactant phase. SLNs serve as carriers for a variety of active compounds. They can offer the systems prepared with many benefits, including pharmacological defense against chemical and enzymatic degradation, increased physical stability, inclusion of hydrophilic and hydrophobic medicines, considerable ease of synthesis, and administration via many routes. Additionally, allergic reactions are prevented, and hazardous pharmacological side effects are reduced [16], [17].

When paired with a molecular sunscreen, SLNs can improve photoprotection while minimizing negative effects because they have UV-resistant qualities and function as physical sunscreens on their own.

Additionally, they have an occlusive quality that might raise the skin's water content and hence enhance skin hydration [18].

Nanostructured Lipid Carriers (NLC), to address the issues with SLNs, NLCs were created. When solid lipids and incompatible liquid lipids are combined, amorphous solids with a preferred ratio of 70:30 to 99.9:0.1 are produced, which are solid at body temperature [18], [19]. The three basic types of NLCs are imperfect, amorphous, and many types. The structure is developed in accordance with the formulation composition and manufacturing parameters on the basis of this division. The size of the particles varies from 10 to 1000 nm. Due to the deformed structure that helps provide more space, NLC exhibits a greater drug loading capacity for the entrapped bioactive chemical as compared to SLN [18]. They are simple to include in skincare items including creams, lotions, and gels [20].

Nanoemulsions, aqueous, oily, and surfactant-based emulsions are heterogeneous dispersed systems made up of two or more immiscible liquids. Droplet diameters for nanoemulsions typically range from 20 to 500 nm.

Because they are made up of such tiny droplets, they have a variety of uses. In particular, nanoemulsions stand out for their outstanding stability and lack of flocculation or coalescence during long-term storage.

Nanoemulsions also have a translucent appearance since the droplet size is much smaller than the visible light wavelength. In comparison to microemulsions, they also have the benefit of being less sensitive to variations in dilution, temperature, and pH [21]-[23].

Nanoemulsions have been employed for topical, ocular, intravenous, and oral drug administration, among other drug delivery methods. Nanoemulsions have the ability to solvate medicines that are not water soluble due to their lipophilic nature. Since the dispersed phase of O/W nanoemulsions allows for better solubility of lipophilic pharmaceuticals in the oil phase, topical treatments manufactured as nanoemulsions are said to have advantages in dermocosmetics. Additionally, the continuous phase offers a calm setting for skin application that can breakdown biopolymers, enhancing look and texture [23], [24].

Niosomes, the interaction of non-ionic surfactants and cholesterol in an aqueous phase gives niosomes their bilayer shape.

This kind of nanoparticle stands out due to its biodegradability, biocompatibility, non-immunogenicity, stability, and capacity for sustained drug administration to the target location [25], [26]. Niosomes can be administered topically, parenterally, or orally to target the site of action, and the vesicles can serve as reservoirs to release the medication gradually. Niosomes demonstrate their capacity to enhance drug stability, enhance component bioavailability, and enhance skin penetration in the context of cosmetic and skin care applications [27], [28].

Polymeric nanoparticles, drug delivery systems known as polymeric nanoparticles have minimum sizes of 100 nm, with the majority falling between 100 and 500 nm. Their primary quality is their capacity to contain active substances that have been adsorbed on the polymeric core's surface. Included are both nanocapsules and nanospheres, which can be identified by their form. The medication dissolves in the oily body of a nanocapsule, which is encased in a polymeric coating that regulates the drug's release profile. On the other hand, oil is not a component of the nanospheres. The medicine is able to be maintained or absorbed uniformly because they are composed of a continuous polymeric network [29], [30].

These substances are unique in that they are non-toxic, biodegradable, and biocompatible. For this reason, polymeric nanoparticles with regulated releases are used. Polymeric particles are employed in skincare and anti-aging products in dermocosmetics because they have the ability to shield drugs and other chemicals from the environment. Additionally, it can be used to treat skin diseases such eczema, psoriasis, acne, and cutaneous mycosis [30], [31].

Dendrimers, the creation of dendrimers, multivalent hyperbranched soft matter nanoparticles, should result in monodisperse molecules. They start with a nucleus, onto which one or more succeeding branches are grafted, much like a tree.

Multivalent nano-objects with tunable surface group additions are produced at the end of the synthesis and are typically made with a specific use in mind [32]. Its characteristics, including monodispersity, adaptability, and durability, make it the ideal carrier for the precise and selective delivery of pharmaceuticals. Target end groups must be changed for physiologically active compounds to bind to them. Because the medications are embedded inside and attach to the surface of dendrimers, they offer a controlled release from the inner core. They are helpful in various cosmetic products such as shampoos, sunscreens, hair styling gels, and anti-acne products [18].

Gold Nanoparticles, due to their simple production, chemical stability, and distinctive optical features, nanoparticles are a desirable material for biomedical research and development. The cell membrane can apparently be easily crossed by 14nm gold nanoparticles, which then gather in the vacuole. These have been demonstrated to result in aberrant actin filaments, extracellular matrix structures, decreased cell proliferation, adhesion, and motility, as well as altered intracellular matrix protein synthesis. Another study also revealed that the enormous surface area of the gold nanoparticles enhanced keratinocyte cell adhesion and proliferation, suggesting a potential use for them in biomedical materials for skin tissue engineering [33].

Silver Nanoparticles, which range in size from 1 to 100 nm and have antibacterial and antimicrobial capabilities, are clusters of silver atoms that are employed in energy storage and conversion as well as medical and pharmaceutical applications. Due to the surface-volume connection, their physical, chemical, and biological characteristics can vary greatly. Although the exact process by which nanoparticles confer antimicrobial activity is still unknown, it has been established that they stick to cell membranes and interact with proteins that contain sulfur. Additionally, silver in water emits ions that have a direct impact on bacteria [34], [35].

B. *Applications of Nanoparticles in Dermocosmetics*

Facilitate skin penetration, the ability of pharmacological compounds applied topically to penetrate the skin and the release of active ingredients at the proper location and dosage determine a topical treatment's effectiveness. Most topical treatments' ability to transfer molecules to the deeper targets of the skin's layers is significantly hindered by the stratum corneum [36].

A molecule needs to have certain physicochemical characteristics, such as a low molecular weight, to be soluble in water and oil with an intermediate distribution coefficient and a low melting point, in order to readily permeate the stratum corneum. These optimal qualities are only found in a select few substances. Others scarcely penetrate the skin barrier or the active ingredient does not reach the site of action in sufficient concentration, failing to have the desired topical or systemic impact. In comparison to traditional pharmaceutical forms, liposomes are a sort of nanoparticle that greatly facilitates penetration into the corneal layer because of their tiny size and structural similarities to the skin while maintaining their lipid content [37].

It is essential to develop more efficient methods to boost the skin's ability to absorb active molecules in order to deliver the necessary quantities at the target region and, as a result, improve the efficacy of topical treatments. Nanometric carrier technologies for cutaneous administration of active chemicals provide tremendous promise in this context. Numerous studies have shown that the ability to target active ingredients to certain skin locations makes nanocarrier systems preferable to conventional formulations. This provides a delayed and controlled release, boosting topical bioavailability, lowering the risk of user side effects, extending the time the drug spends in the skin, and enhancing chemical stability of the compounds. And other crucial factors that contribute to improving treatment effectiveness, decreasing dosage frequency, and ensuring patient compliance [36].

Because NLCs and SLNs adapt to medications including imidazole antifungals, isotretinoin, ketoconazole, flurbiprofen, and glucocorticoids, they are frequently employed for topical delivery. In order to target the epidermis, podophyllotoxin-SLN must penetrate through the stratum corneum and along the skin's surface. The cumulative absorption of isotretinoin into the skin is increased by isotretinoin-loaded nanoparticles designed for topical delivery utilizing the heat homogenization method. The creation of flurbiprofen-loaded SLN gels may have advantages in that they can carry medication through the skin to the site of action, resulting in larger tissue concentrations [38].

Sun protection, numerous dangerous diseases and skin damage are mostly brought on by excessive UV light exposure.

Long-term negative consequences (on all skin cancer) are a particular cause for concern in society, in addition to direct evident acute harm like sunburn or polymorphic light flare.

Because of this, many everyday skin and hair care products now contain cosmetic ingredients with UV filters [39], [40].

Due to some chemicals' skin permeability, conventional sunscreens are typically emulsions, gels, or oils with constraints on washability, stability, and toxicity. Benefits of adding UV-vis filters to nano-sized carriers include increased sun protection over UV-vis filters alone, reduced photodegradation of organic filters, reduced toxicity hazards, and less incompatibility between formula ingredients. Lipid, gelatin, polymer, or silica nanostructures may make up these carriers [41].

Depending on how they work, UV filters can be divided into two primary categories: chemical sunscreens, also known as organic filters, and physical sunscreens, also known as inorganic or mineral filters. Chemical sunscreens are composed of molecules that may absorb UV radiation and disperse the absorbed energy in different ways. Contrarily, physical sunscreens offer broad-spectrum protection by absorbing, reflecting, and dispersing both UVA and UVB radiation, which stops ultraviolet light from penetrating the skin [42]. Physical filters are often made of intrinsically UV-absorbing metal oxide particles like zinc oxide (ZnO) and titanium dioxide (TiO2). Physical UV blockers in sunscreens successfully shield cells from UV-induced DNA damage [43].

Nanoparticles made of ZnO and TiO_2 are utilized in sunscreens. Since they are significantly less noticeable after application due to their smaller size, customers are more likely to accept these mineral particles. TiO_2 offers superior UVB protection whereas ZnO has a wide UVA-UVB absorption curve. Given the absence of percutaneous absorption, inorganic filters pose very little health risk to people. However, utilizing aerosol sunscreen products with nanoparticles is not advised because there may be a danger of inhalation exposure [44].

To lessen the photocatalytic activity of ZnO and TiO_2 nanoparticles, silica can be utilized to cover their surfaces. SiO_2 nanoparticles can also be used as organic filter carriers because silica nanoparticle synthesis research is well developed. SiO_2 nanoparticles scatter UV rays and work in concert with other filters to increase SPF values. Mesoporous silica nanoparticles are one type of structure that has a large loading capacity and incorporates UV filters inside the pores [41].

Furthermore, it has been demonstrated that solid lipid nanoparticles, lipid nanoparticles with a nanostructure, and lipid nanoparticle carriers with a nanostructure can combine the advantages of organic and inorganic sunscreens to enhance photoprotection. Due to the high quantities of surfactants or alcohol used in classic sunscreen formulations, when these products are submerged in water when swimming or perspiring, the sunscreen is either entirely or partially washed away. It was proposed to formulate them as oils to lengthen the product's stay on the skin, but these formulations leave the user's skin with a very unpleasant sensation.

Due to their size, lipid nanoparticles adhere strongly to surfaces. In order to get the best level of sun protection, this enables sunscreens to stay on the skin for longer and require fewer applications [45].

C. *Moisturizing Agents*

Moisturizers, also known as humectants, are a medicinal tool used to treat various skin conditions like eczema, psoriasis, and itching. The stratum corneum of the skin becomes dry and less flexible when water is removed from it. The creation of osmolytes like betaine, whose purpose is to stop water loss, is made possible by the action of cutaneous phospholipases. Because they have the ability to penetrate the stratum corneum of the skin, liposomes made of unsaturated phospholipids are utilized in formulations that are meant to have a moisturizing effect [1], [46]. The type of liposomes that are employed can be determined by how many phospholipid layers they include; they can be single layers or multilayers. The multilamellar structured liposome is considered more effective than the monolamellar in the sustained release and transdermal deposition of bioactive ingredients [47].

Due to various therapies, the stratum corneum's barrier function may frequently be insufficient to shield the skin from allergens or other pathological disorders including dermatitis and allergies. Supporting the barrier function of the skin is crucial under these circumstances. It was discovered that SLNs were more advantageous than common creams. SLNs can better guard against skin dehydration and lower hazards like eczema.

Regular moisturizers may not be as efficient as C creams with high-lipid SLNs [38].

Lipid nanoparticles have also demonstrated promise for dermatological and cosmetic applications due to their numerous benefits over alternative topical delivery methods. The small size of the particles guarantees intimate contact with the stratum corneum, increasing skin hydration and minimizing transepidermal water loss.

This is advantageous for treating and avoiding skin conditions characterized by a compromised skin barrier function. Additionally, they have low toxicity and cytotoxicity and can modulate medication release.

With a nanoscale particle size range of roughly 40 to 1000 nm, lipid nanoparticles are based on a natural or synthetic lipid matrix, found in a solid state at room and body temperatures [48].

D. *Anti-aging Agents*

While wrinkles form as a result of the impacts of time and environmental variables, aging is a progressive and degenerative process that results in functional and structural abnormalities of the skin, including noticeable changes in the extracellular matrix and expression of integrins. Inflammation brought on by an excess of pro-inflammatory cytokines, together with dysregulation and disruption of the cellular redox balance brought on by harmful reactive oxygen species and reactive nitrogen species, are intimately correlated with these changes. Consequently, hyperoxia or insufficient oxygen metabolism appear to be present in oxidative stress.

Skin lesions and accelerated aging are caused by these occurrences that interfere with the biological activity of cells [49].

Additionally, since nanoparticles may reach deeper layers of the skin, it is anticipated that ingredients such as vitamin E and retinol, among other anti-aging agents, will function more effectively. A revitalizing lotion with silk microfibers and 24-karat gold nanoparticles is sold in the market. Being a natural protein, it is meant to function as a potent hydrating, anti-inflammatory, and antioxidant preparation. These substances should be able to penetrate cells with the aid of nanotechnology and speed up skin healing [50].

In order to moisturize, lift, and whiten the skin, a number of artificial and natural anti-aging lotions incorporating nanotechnology are currently on the market. Through multiple antioxidant mechanisms, nano-sized phyto-bioactive substances like curcumin and vegetable oils improve the appearance of the skin. Some products containing these compounds prevent skin aging due to oxidative stress and premature aging. Eysenhardtia platycarpa leaf flavanones were recently used to create a nanoemulsion system with 70nm nanoparticles that improve anti-aging efficacy [51].

E. *Cleaning Agents*

The goal of cleansers, which are surfactant substances, is to lower the skin's surface tension and get rid of dirt, sebum, bacteria, and dead cells. The best cleansers should have emulsifying capabilities without causing irritation, harm, or changing the skin's moisture barrier [52]. The cleaning agents are synthetic, less caustic-to-the-skin syndets or alkaline soaps. To prevent stinging and dryness, these cleaning solutions contain a pH range (5.5-7) that is close to that of the skin. Due to the charge density of micellar-like surfactant aggregates bound to proteins, these properties are related to their decreased propensity to cause protein denaturation [53]. The skin can maintain more cleanliness when treated with silver nanoparticles, which also serve as disinfectants and decontaminants. The company Nano Cyclic Inc produces a cleansing soap called Nano Cyclic, a scientifically balanced blend of nanosilver and natural ingredients used to cleanse the skin [9].

To enhance skin cleansing, several plant-based nanocomposites are being researched. Reducing the size of the skin's pores and oil production, plant-based extracts used in cleansers recently demonstrated enhanced skin cleansing action. There has been substantial research on the use of plant-based substances for skin cleansing and in relation to skin conditions like acne. The 113 nm size range of the nanometric liposomal lauric acid was used in its construction, and it demonstrated improved antibacterial action against acne. Another study revealed improved antibacterial action against skin infections brought on by acne when niosomes containing a mixture of lauric acid and curcumin were utilized. According to these investigations, skin cleansing activity is improved in skin illnesses by plant-based nanotechnologies [51].

F. *Skin Whitening Agents*

It is essential to hunt for a method that enables vitamin derivatives, amino acids, and other active substances to be obtained in nanoparticles to reach the target areas steadily and retain the pharmacological action for a long time for skin whitening and anti-wrinkle applications. Therefore, it is crucial to consider developing nanoparticles as drug delivery systems for cosmetic applications. In one study, vitamin C, vitamin E, and vitamin A derivatives were encapsulated in PLGA nanospheres to create a new kind of functional skincare product. Melanocytes in the dermis' fibroblasts and melanocytes in the epidermis' basal layer are both penetrated by PLGA nanospheres, then over the course of 48 hours, due to hydrolysis by skin moisture, gradually release their vitamin derivatives. These compounds are converted into pure vitamins by esterase in the body and show a pharmacological effect near the desired area [54].

Skin can look better when arbutin nanoparticles are applied. Arbutin, a naturally occurring hydroquinone derivative, can reduce tyrosinase activity and hence reduce melanogenesis. One of the most popular skin-whitening treatments, a-arbutin is less harmful than hydroquinone [55]. A product containing arbutin might be applied topically to treat skin issues like age spots, dullness, and unwelcome pigmentation. It is possible to create a cosmetic whitening composition with arbutin in nanoparticles with a particle size of 10-150 nm (1-15% by weight), created by subjecting an aqueous dispersion of arbutin to a nanoparticle-forming process. Tyramine derivatives can also be employed as nanoparticles since they have stronger melanogenesis inhibiting effect than tyramine itself [56].

G. Antibacterial Agent

Metallic nanoparticles are now used as antibacterial agents as a result of scientific advancements. In plant dermatological treatments, silver and zinc nanoparticles act as microbicidal agents. In the follicle, the metallic nanoparticles gather. Here, a deposit is created that enables the slow absorption of nanoparticles into the blood capillaries from the follicles [57]. Streptococcus mutans, Streptococcus salivarius, and Streptococcus mitis have all been demonstrated to be susceptible to the bactericidal effects of silver nanoparticles in the form of a colloidal solution. Furthermore, it has been demonstrated that Staphylococcus strain growth is inhibited by nano metal oxides such zinc oxide and titanium oxide nanoparticles [33].

H. Makeup Removers

In a cosmetic formulation, L'Oreal used a nanoemulsion system based on micelles created from dispersions of micellar nanoparticles loaded with oily components that made it easier to utilize a surfactant made of a block copolymer of polyethylene oxide and polypropylene. Fluid makeup remover, makeup removal gel, and eye lotion were developed as micelles-based cosmetics. Micellar nanoparticles of oils with a molecular weight more than 400 and a mean particle diameter of less than 100 nm are used to disseminate these cosmetic segments [58].

IV. Conclusion

Due to the numerous benefits that nanoparticles offer in the production of pharmaceuticals, cosmetics, and medical equipment, among other things, the use of nanotechnology has experienced a rapid growth in the biomedical business and the cosmetic industry. Nanoscale cosmetic solutions with enhanced penetration, localization, protection, stability, and controlled release of active substances are now possible thanks to nanotechnology.

The cosmetics business uses a variety of nanoparticles. They include dendrimers, gold and silver nanoparticles, liposomes, ultrasomes, photosomes, nanocrystals, solid lipid nanoparticles, nanostructured lipid carriers, nanoemulsions, niosomes, polymeric nanoparticles, and photosomes. Each of these varieties has a unique structure. They are used in various skincare treatments as a result.

The primary uses of nanotechnology in dermocosmetics are to improve the effectiveness of topical treatments by allowing molecules to penetrate the skin more easily, to create UV protection products, and to create moisturizing and anti-aging skin care products. Nanoparticles are also used in the production of skin-cleansing and whitening products, antibacterial products, and makeup removers. Although the use of nanotechnology in the cosmetics business has increased dramatically in recent years, much more research is still needed to determine its safety and toxicity for both humans and the environment.

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Conflict of Interest

The authors state that there is no conflict of interest with the research carried out in this article.

References

[1] Salvioni L, Morelli L, Ochoa E, Labra M, Fiandra L, Palugan L, et al. The emerging role of nanotechnology in skincare. *Adv Colloid Interface Sci*. 2021; 293: 102437.

[2] Muda H, Aziz A, Taher ZM, Aziz RA. Recent Trends in *Malaysia Medicinal Plants Research, Skudai, Johor: Penerbit UTM Press*, 2017: 126-175.

[3] Bayda S, Adeel M, Tuccinardi T, Cordani M, Rizzolio F. The history of nanoscience and nanotechnology: from chemical-physical applications to nanomedicine. *Molecules*. 2019; 25(1): 112.

[4] Bissessur R. Nanomaterials applications: Elsevier, 2020: 435-453.

[5] Nohynek GJ, Dufour EK, Roberts MS. Nanotechnology, cosmetics, and the skin: is there a health risk? *Skin Pharmacol Physiol*. 2008; 21(3): 136-149.

[6] Manikanika, Kumar J, Jaswal S. Role of nanotechnology in the world of cosmetology: A review. *Mater Today Proc*. 2021; 45(2): 3302-3306.

[7] Mu L, Sprando RL. Application of nanotechnology in cosmetics. *Pharm Res*. 2010; 8: 1746-1749.

[8] Hameed A, Fatima GR, Malik K, Muqadas A, Fazal-your-Rehman M. Scope of nanotechnology in cosmetics: dermatology and skincare products. *J Med Chem Sci*. 2019; 2: 9-16.

[9] Lohani A, Verma A, Joshi H, Yadav N, Karki N. Nanotechnology-based cosmeceuticals. *ISRN Dermatol*. 2014; 14: 1-16.

[10] Wu X, Guy RH. Applications of nanoparticles in topical drug delivery and in cosmetics. *J Drug Deliv Sci Technol*. 2009; 19(6): 371-384.

[11] Pepakayala H, Battu G, Pidaparthy LM, Pilaka S, Devi A, Vasu P, et al. A review on ultrasome drug delivery systems. *International Journal of Biomedical Nanoletters*. 2021; 1: 17-21.

[12] Santos AC, Morais F, Simões A, Pereira I, Sequeira JAD, Pereira-Silva M, et al. Nanotechnology for the development of new cosmetic formulations. *Expert Opin Drug Deliv*. 2019; 4: 313-330.

[13] Hougeir FG, Kircik L. A review of delivery systems in cosmetics. *Dermatol Ther*. 2012; 25(3): 234-237.

[14] Patravale VB, Mandawgade SD. Novel cosmetic delivery systems: an application update. *Int J Cosmet Sci*. 2008; 30(1): 19-33.

[15] Shegokar R. What nanocrystals can offer to cosmetic and dermal formulations. In: Grumezescu AM, editor. *Nanobiomaterials in Galenic Formulations and Cosmetics*. 2016: 69-91

[16] Geszke-Moritz M, Moritz M. Solid lipid nanoparticles as attractive drug vehicles: Composition, properties, and therapeutic strategies. *Mater Sci Eng C*. 2016; 68(1): 982-994.

[17] Duan Y, Dhar A, Patel C, Khimani M, Neogi S, Sharma P, et al. A brief review on solid lipid nanoparticles: part and parcel of contemporary drug delivery systems. *RSC Adv*. 2020; 45: 26777-26791.

[18] Kaul S, Gulati N, Verma D, Mukherjee S, Nagaich U. Role of nanotechnology in cosmeceuticals: a review of recent advances. *J Pharm*. 2018; 18: 1-19.

[19] Patel D, Tripathy S, Nair S, Kesharwani R. Nanostructured lipid carrier (NLC) a modern approach for topical delivery: a review. *WORLD J Pharm Pharm Sci*. 2013; 2(3): 921-938.

[20] Müller RH, Alexiev U, Sinambela P, Keck CM. Nanostructured Lipid Carriers (NLC): The Second Generation of Solid Lipid Nanoparticles. In: Dragicevic N, Maibach HI, editors. *Percutaneous Penetration Enhancers Chemical Methods in Penetration Enhancement.* 2016: 161-185.

[21] Chiari-Andréo BG, Almeida-Cincotto MGJ de, Oshiro JA, Taniguchi CYY, Chiavacci LA, Isaac VLB. Nanoparticles for cosmetic use and its application. In: Grumezescu AM, editor. *Nanoparticles in Pharmacotherapy*.2019: 113-146.

[22] Gupta A. Nanoemulsions. In: Chung EJ, Leon L, Rinaldi C, editors. *Nanoparticles for Biomedical Applications*.2020: 371-384

[23] Gupta A, Eral HB, Hatton TA, Doyle PS. Nanoemulsions: formation, properties, and applications. *Soft Matter*. 2016; 11: 2826-2841.
[24] de Campos VEB, Ricci-Júnior E, Mansur CRE. Nanoemulsions as delivery systems for lipophilic drugs. *J Nanosci Nanotechnol*. 2012; 12(3): 2881-2890.
[25] Mahale N, Thakkar P, Mali RG, Walunj DR, Chaudhari S. Niosomes: Novel sustained release non-ionic stable vesicular systems-An overview. *Adv Colloid Interface Sci*. 2012; 183-184: 46-54.
[26] Ag Seleci D, Seleci M, Walter J-G, Stahl F, Scheper T. Niosomes as nanoparticular drug carriers: fundamentals and recent applications. *J Nanomater*. 2016; 16: 1-14.
[27] Gill IK, Panwar N, Sharma R. A review on novel drug delivery system research & reviews. *Pharm Nanotechnol*. 2016.
[28] Chen S, Hanning S, Falconer J, Locke M, Wen J. Recent advances in non-ionic surfactant vesicles (niosomes): Fabrication, characterization, pharmaceutical and cosmetic applications. *Eur J Pharm Biopharm.* 2019; 144: 18-39.
[29] Zielińska A, Carreiró F, Oliveira AM, Neves A, Pires B, Venkatesh DN, et al. Polymeric Nanoparticles: Production, Characterization, Toxicology, and Ecotoxicology. *Molecules*. 2020; 25(16): 3731.
[30] Castro KC de, Costa JM, Campos MGN. Drug-loaded polymeric nanoparticles: a review. *Int J Polym Mater Polym Biomater*. 2020; 71(1): 1-13.
[31] Bahamonde-Norambuena D, Molina-Pereira A, Muñoz M, Zepeda K, Vilos C. Polymeric Nanoparticles in Dermocosmetic*. Int J Morphol. 2015*; 33(4): 1563-1568.
[32] Fruchon S, Poupot R. Pro-Inflammatory Versus Anti-Inflammatory Effects of Dendrimers: The Two Faces of Immuno-Modulatory Nanoparticles. *Nanomaterials*. 2017; 9: 251.
[33] Niska K, Zielinska E, Radomski MW, Inkielewicz-Stepniak I. Metal nanoparticles in dermatology and cosmetology: interactions with human skin cells*. Chem Biol Interact*. 2018; 295: 38-51.
[34] Helmlinger J, Sengstock C, Groß-Heitfeld C, Mayer C, Schildhauer TA, Köller M, et al. Silver nanoparticles with different size and shape: equal cytotoxicity, but different antibacterial effects. *RSC Adv*. 2016; 22: 18490-18501.
[35] Xu L-C, Siedlecki CA. Antibacterial polyurethanes. In: Cooper SL, Guan J, editors. Advances in Polyurethane Biomaterials. *Woodhead Publishing*. 2016; 247-284.
[36] Gökçe BB, Güngör S. Nanocarrier-mediated follicular targeting. In: Nanda A, Nanda S, Nguyen TA, Rajendran S, Slimani Y, editors. *Nanocosmetics*.2020: 305-326
[37] Ahmadi Ashtiani HR, Bishe P, Lashgari N-A, Nilforoushzadeh MA, Zare S. Liposomes in Cosmetics*. J Skin Stem Cell*. 2016; 3(3): e65815.
[38] Newton AMJ, Kaur S. Solid lipid nanoparticles for skin and drug delivery: Methods of preparation and characterization techniques and applications. In: Grumezescu AM, editor. *Nanoarchitectonics in Biomedicine*. 2019: 295-334.
[39] Stiefel C, Schwack W. Photoprotection in changing times-UV filter efficacy and safety, sensitization processes and regulatory aspects. *Int J Cosmet Sci*. 2015; 37(1): 2-30.
[40] World Health Organization. *Global solar UV index: a practical guide* [Internet]. 2002. Available from: https://apps.who.int/iris/handle/10665/42459
[41] Tonolli PN, Teixeira T, Baptista M. Nanocosmetics for broadband light protection sun care products. In: Nanda A, Nanda S, Nguyen TA, Rajendran S, Slimani Y, editors. *Nanocosmetics.* 2020: 185-203.
[42] Gubitosa J, Rizzi V, Fini P, Cosma P. Nanomaterials in sun-care products. In: Nanda A, Nanda S, Nguyen TA, Rajendran S, Slimani Y, editors. *Nanocosmetics*.2020: 349-373
[43] Osmond MJ, McCall MJ. Zinc oxide nanoparticles in modern sunscreens: an analysis of potential exposure and hazard. *Nanotoxicology*. 2010; 4(1): 15-41.
[44] Schneider SL, Lim HW. A review of inorganic UV filters zinc oxide and titanium dioxide. *Photodermatol Photoimmunol Photomed*. 2019; 35(6): 442-446.
[45] Nikolić S, Keck CM, Anselmi C, Müller RH. Skin photoprotection improvement: Synergistic interaction between lipid nanoparticles and organic UV filters. *Int J Pharm*. 2011; 414(1-2): 276-284.
[46] Sharma B, Sharma A. Future Prospect of Nanotechnology in development of anti-agein formulations. *International Journal of Pharmacy and Pharmaceutical Sciences*.2012; 4: 57-66.
[47] Yang S, Liu L, Han J, Tang Y. Encapsulating plant ingredients for dermocosmetic application: an updated review of delivery systems and characterization techniques*. Int J Cosmet Sci*. 2020; 42(1): 16-28.
[48] Souza C, de Freitas LAP, Maia PMBG. Topical Formulation Containing Beeswax-Based Nanoparticles Improved In Vivo Skin Barrier Function. *AAPS Pharm Sci Tech*. 2017; 18(7): 2505-2516.
[49] Morganti P, Morganti G, Coltelli MB. Skin and pollution: the smart nano-based cosmeceutical-tissues to save the planet's ecosystem. In: Nanda A, Nanda S, Nguyen TA, Rajendran S, Slimani Y, editors. *Nanocosmetics*.2020: 287-303
[50] Nanda S, Nanda A, Lohan S, Kaur R, Singh B. Nanocosmetics: performance enhancement and safety assurance. In: Grumezescu AM, editor. *Nanobiomaterials in Galenic Formulations and Cosmetics*.2020: 47-67.
[51] Ganesan P, Choi D-K. Current application of phytocompound-based nanocosmeceuticals for beauty and skin therapy. *Int J Nanomedicine*. 2016; 11: 1987-2007.
[52] Kuehl B, Fyfe K, Shear N. Cutaneous cleansers. *Skin Ther Lett*. 2003; 8(3): 1-4.
[53] Draelos ZD. The science behind skincare: Cleansers. *J Cosmet Dermatol*. 2018; 17(1): 8-14.
[54] *Development of Functional Skincare Cosmetics Using Biodegradable PLGA Nanospheres,* 3rd ed., Nanoparticle Technology Handbook, Cambridge, MA, 2018: 445-450.
[55] Chandorkar N, Tambe S, Amin P, Madankar C. Alpha Arbutin as a Skin Lightening Agent: A Review. *International Journal of Pharmaceutical Research*. 2021; 13(2): 3502-3510.
[56] Mihranyan A, Ferraz N, Strømme M. Current status and future prospects of nanotechnology in cosmetics. *Prog Mater Sci*. 2012; 57(5): 875-910.
[57] Sánchez E, Gomes D, Esteruelas G, Bonilla L, Lopez AL, Galindo R, et al.Metal-Based Nanoparticles as Antimicrobial Agents: An Overview. *Nanomaterials*. 2020; 10(2): 1-39.
[58] Aziz ZAA, Mohd-Nasir H, Ahmad A, Mohd SH, Peng WL, Chuo SC, et al. Role of Nanotechnology for Design and Development of Cosmeceutical: Application in Makeup and Skincare. *Front Chem*. 2019; 7: 1-15.