Nanomaterials in Cosmetic

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Skin aging is described as dermatologic changes either naturally occurring over the course of years or as the result of the exposure to environmental factors (e.g., chemical products, pollution, infrared and ultraviolet radiations). The production of collagen and elastin, the main structural proteins responsible for skin strength and elasticity, is reduced during aging, while their role in skin rejuvenation can trigger a wrinkle reversing effect. Elasticity loss, wrinkles, dry skin, and thinning are some of the signs that can be associated with skin aging. To overcome skin aging, many strategies using natural and synthetic ingredients are being developed aiming to reduce the signs of aging and/or to treat age-related skin problems (e.g., spots, hyper- or hypopigmentation). Among the different approaches in tissue regeneration, the use of nanomaterials loaded with cosmeceuticals (e.g., phytochemicals, vitamins, hyaluronic acid, and growth factors) has become an interesting alternative. Based on their bioactivities and using different nanoformulations as efficient delivery systems, several cosmeceutical and pharmaceutical products are now available on the market aiming to mitigate the signs of aged skin.

Keywords: Nanomaterials

1. Introduction

Nanotechnology stands for the production and use of materials at the nanoscale, which show physicochemical properties different from their bulk counterparts. Due to special rearrangements of their inner structure, these new materials exhibit a larger surface area, thereby acting differently with biological systems [1]. The loading of active pharmaceutical ingredients (APIs) within nano-sized drug delivery systems is being currently exploited to promote product innovation by developing nanoproducts. Nanoproducts used for the delivery of APIs to the skin (e.g., nanopharmaceuticals, nanocosmeceuticals) have already proven their efficacy as several products are already available on the market for the treatment of skin injuries (e.g., atopic dermatitis [2], skin cancer [3], skin burns [4], wound healing [4][5]), and protection from ultraviolet (UV) radiations [6][7][8][9][10]. Some examples of daily contact with nanomaterials are given in Figure 1. A successful example is the formulation of sunscreens into nanoproducts. This approach was found to decrease the adverse side-effects of UV inorganic filters (e.g., titanium dioxide (TiO_2), zinc oxide (ZnO) [11]) and of chemical filters (benzophenone-3 [7][12]), improving the safety to consumers [8][9][10]. Besides, it has also been demonstrated that the loading of sunscreen into solid nanoparticles can offer a synergistic effect, as nanoparticles can themselves have a sun-blocking effect [13].

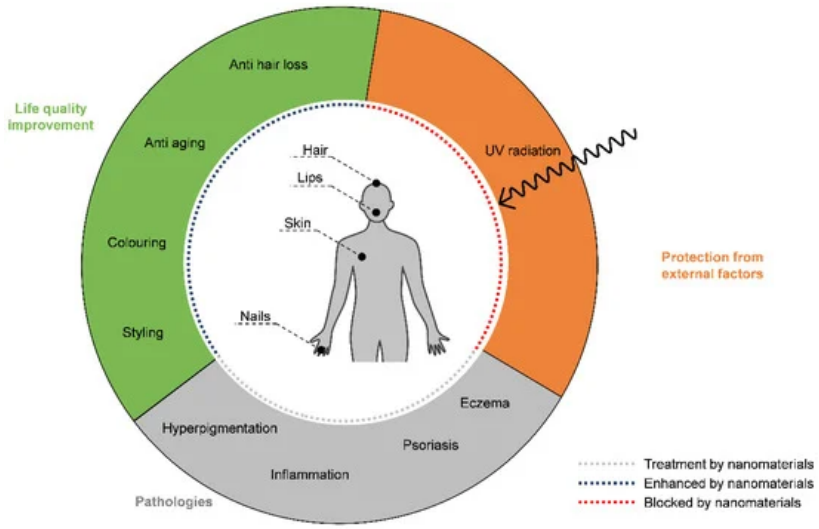

Figure 1. Applications of nanomaterials in the formulation of cosmetics and other products for topical application and their interaction with everyday human activities. Nanomaterials used in hair and skin care products promote quality of life by offering innovations in a range of applications and enhance sunscreen protection. Nanomaterials are also used as delivery system for a range of active pharmaceutical ingredients to treat several skin pathologies.

Due to their small size, nanoparticles may exhibit high reactivity and can induce the production of reactive oxygen species (ROS) that promote oxidative stress, DNA damage, proteins and membranes degradation, and inflammation [14][15][16]. The risk assessment of lipid peroxidation and oxidative stress induced by nanoparticles is a commonly recommended procedure [15][17][18]. The bioavailability of an active compound of nutraceutical or pharmaceutical interest [19][20][21][22][23], in the formulation of a cream, lotion, or cosmetic product, is defined by the concentration that reaches in a biological fluid, i.e., blood, which is available for a therapeutic effect. The bioavailability is more influenced by the properties of the dosage form, i.e., the design and formulation rather than of the physicochemical properties of the API. The physicochemical properties of the API influence the amount that will be absorbed [24]. The loading of APIs in nanoparticles is a common strategy to improve their bioavailability in particular for poorly water-soluble compounds. Besides, due to their enhanced surface area in contact with the skin, increased permeation of the skin to the compounds is also expected. Besides bioavailability, the size of the particles is instrumental in defining the toxicological profile, the shelf life, and the efficacy of the final nanoproduct.

2. Types of Nanomaterials Used in Cosmetic Formulations

Due to its large surface area, the skin is an interesting administration route for several APIs. The advantages of topical drug delivery include the possibility to overcome the risk associated with the parenteral administration (e.g., pain, infection), avoidance of first pass metabolism associated with the oral administration of drugs, possibility to extend the treatment for longer timeframe which allows the use of drugs with small biological half-lives, and consequently reduce the gastrointestinal irritation promoted by the systemic administration. The major challenge encountered in the delivery of APIs through the skin is to overcome the different physiological layers of distinct polarity. Skin is known to protect the body from xenobiotics, which can be not only toxic agents and pathogens, but also drugs, while ensuring the expulsion of physiological fluids for homeostasis. As the permeation of the skin to the API compromises its absorption, the bioavailability of APIs administered topically is smaller in comparison to oral and intravenous routes [25]. Different types of nanoparticles (including Nanoemulsions, Solid Lipid Nanoparticles (SLN) and the Nanostructured Lipid Carriers (NLC), Nanocrystals, Dendrimers, Dendrimers, Dendrimers, Metal Nanoparticles, Polymeric Nanoparticles, Carbon Nanotubes, Polymersomes, Polymersomes, etc.) have been proposed to overcome the difficulty encountered in skin administration of APIs.

3. Nanomaterials in Anti-Aging Formulations

The use of nanomaterials in cosmetics is the fastest growing segment within the personal care industry. Table 1 lists several of these products that are already available on the market. Skin care cosmetic products act against the harmful effects of free radicals and pollution, and therefore improve skin texture and function, improving the maintenance of collagen structure and thus the strength of skin. Consequently, a healthier skin is obtained. Other skin structures that benefit from anti-aging cosmeceutical formulations are the keratins (fibrous structural protein, present in structures as hair, skin, nails) and elastin (extracellular matrix protein, necessary to maintain skin elasticity). Products as Agera Nano Eye Lift, incorporate growth factor peptides, retinol and retinyl palmitate that stimulate the production of collagen and epidermal cell proliferation, helping to smooth fine lines and wrinkles. Products from Bionova-Nano Skin Tech, designed to protect and treat the skin in various situations, uses co-encapsulations of various bioactive molecules (e.g., antioxidants, oils, proteins, drugs, sunscreens) according to the product aim. Sunscreens with zinc oxide and titanium dioxide in their composition are the most effective in skin protection, originating less greasy products, with less smell and transparent aspect [26]. Given that SLN, nanoemulsions, liposomes, and niosomes have the ability to keep the skin hydrated, due to the formation of a film of humectants that retain moisture for a longer period, they are widely used in moisturizing formulations. In the case of anti-aging cosmetics, the main products that are available consist in the use of nanocapsules, liposomes, nanosomes, and nanospheres for the loading of skin cosmeceuticals. Nanoformulations used in shampoos retain the moist within the cuticles increasing the contact time with scalp and hair follicles due to a formation of a protective film [27]. Conditioning nanocosmetic agents were created to increase the softness, shine, silkiness, gloss, and disentangling of hair. The newest developments in hair care use niosomes, microemulsion, nanoemulsion, nanospheres, and liposomes, aiming the repair of damaged cuticles, restoration of hair texture and gloss, and to keep the hair shinier, less greasy, and less brittle [28].

Table 1. Anti-aging products available to consumers and their respective purposes.

Brand-Product	Characteristics and Uses

Agera®-Nano Eye Lift	Anti-aging skin care. Make the skin around the eyes softer
Bionova-Nano Skin Tech Tennis Player Sun and Wind Protection	Confers UV protection, using nanocomplex of naturally existing UV Chromophores and UV Protectant. Increase the protection against the sun radiation. Widely used in dry skin (nanocomplex of multiple antioxidants, oil, water-soluble vitamins with their specific coenzymes)
Chantecaille-Nano Gold Energizing Cream	Anti-aging power due to the incorporation of 24-karat gold and silk bound, together with pullalan/algae and plantago extracts, and other natural antioxidants (vitamin E) and natural oils. Decrease significantly the lines, wrinkles, dullness and the dehydration. Antioxidant and anti-inflammatory activity.
StriVectin™-Specialised Hand Care System	Offers specialized hand care, for the treatment of age and/or sun spots, ageing skin, fine Lines and wrinkles. NanoExfoliate action (with thermo-active formula, exfoliate without causing redness or damage on the skin). Hand Cream ultra-concentrated to nourish, protect and hydrate the hand's skin (contains hyaluronic acid, UV blockers, etc).
Rosactive® Phytoceutical Skin care-Biomixyl	Anti-aging line with several products designed to reduce wrinkles and lines by stimulating collagen production, using a bio-peptide complex and natural oils and extracts from several plants.
Salcura® Natural Skin Therapy—e.g., Bioskin Zeoderm Skin Repair System	The products consist of natural colloidal solution delivery systems based on biotechnology and nanotechnology. Aimed to treat dry skin and irritation symptoms, uses natural extracts, oils and other ingredients. Used for the treatment of diseases, such as, eczema, psoriasis, dermatitis and other skin allergies.
Shakti® Face and Body Resculpting Cream™	With encapsulated black currant seed oil (also contains amino-acids, vitamin C, oil from fragrant Bulgarian roses, etc.), to promote natural antibacterial and anti-inflammatory action, while conferring lifting and moisturizing to the skin from head to toe.
Nanoceuticals™ Citrus Mint Shampoo	With nanoscale ingredients (in suspended nanoparticles), allow the scavenging of free radicals, the stimulation of the source energy, increased hydration, the balance of pH, and others. Nanoparticles in the composition provide to the hair a healthy shine.
Serge Lutens Blusher (Barneys New York®) Nano Dispersion technology	Make up products produced with resource to nanotechnology. Due to the dispersion technology, this powder has excellent elasticity, extreme softness and light diffusion.
Apagard® Royal-Sangi	It is a re-mineralizing toothpaste (contains nano medical hydroxyapatite for protection against caries). Promotes oral health by preventing caries, remineralization and whitening using natural healing.

4. Conclusion

Nanomaterials-based products are increasingly growing and reaching different markets over the last few decades, e.g., dermatology, cosmetics, and pharmaceutics. Several types of nanomaterials, e.g., liposomes, niosomes, SLN, NLC, gold nanoparticles, polymeric nanoparticles, and nanoemulsions, have been proposed for the delivery of cosmetic ingredients, as they are produced from biocompatible materials. The developed nanocosmeceutical shows enhanced stability, biocompatibility, and has a prolonged action and capacity to improve skin delivery of the payload. Nanoemulsions are an example of great improvements in the cosmetic field. Their use in personal care products benefits from the possibility to have a controlled delivery of cosmeceuticals, together with a more uniform delivery onto the skin through the formation of

a thin film. Skin aging is a complex process that can be caused by endogenous and/or exogenous factors. Almost 90% of the skin aging processes are caused by the exposure to the UV radiation. The lifestyle is another factor that influences the progression of skin aging (e.g., stress, smoking, sleeping, and alcoholic habits), also the environmental factors (e.g., pollution), malnutrition, and so on. The first signs of skin aging include dry aspect, loss of skin elasticity, and the appearance of wrinkles. It is nowadays possible to prevent and/or delay the first signs of skin aging. The conventional topical formulations (e.g., solution, suspensions, gels, emulsions, powder, and aerosols) are acceptable for topical delivery of active ingredients; however, all these formulations have some limitations and can compromise the safety and/or effectiveness of the treatment. A range of nanomaterials for the delivery of active ingredients have been developed to overcome these limitations. The continuous development of skin products with active ingredients making use of nanomaterials offers innovative alternatives in health and cosmetic care sectors, with beneficial effects to the industry and society.

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