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Editorial

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Nanocosmetics: The Good, the Bad and the Beautiful

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Nanotechnology has found extensive applications in the field of cosmetics. Nanoscale materials have the potential to enhance the effectiveness and affect the cellular responses associated with various cosmetics. Depending on the type of nanoparticle used, the effects seen may vary.

The common applications of nanoparticles in cosmetics are to enhance their physicochemical properties and the visual appeal of the cosmetic, enhance stability of the actives, modulate penetration of actives, alter the route of penetration (intercellular, transcellular or appendageal), cause site specific accumulation, modulate systemic toxicity of actives or enhance the intrinsic photostability of the cosmetics.[1]

The size of nanocarriers influences their dermal penetration and cellular internalization. This may be utilized for beneficial purposes such as a size dependant accumulation of the nanocarriers may be obtained in various layers of the skin. The effects are specific to each type of nanoparticles and hence there is no common cellular effect of all nanoparticles. Many factors determine the ultimate effect of the nanoparticles in cosmetology.

While size is a major determinant of the effects of nanoparticles in the skin, another important parameter influencing the effects of nanoparticles in cosmetics is their soluble, insoluble, degradable or non-degradable nature. This distinction is evident in the European Union cosmetic regulation which defines nanomaterials as "insoluble or biopersistant and intentionally manufactured materials with one or more external dimensions or an internal structure on a scale of 1 to 100 nm."[2] Cellular responses, residence time and depth of penetration through intact skin can widely vary depending on this property of nanomaterials.

Quantum dots are a group of non-degradable nanoparticles that have been explored in several applications for their optical properties. In general, quantum dots have not been found to penetrate through the stratum corneum; however, there is evidence that some accumulation in the epidermis is possible with changes in pH, surface chemistry of the shell of the quantum dot.[3] Nevertheless, more clarity is required on the biological effects of this group of nanoparticles.

Titanium dioxide and zinc oxide nanoparticles have been widely used in sunscreens.[4] Zinc oxide nanoparticles have often been found to be localized on the surface of the skin and hair follicle shafts without deeper penetration. Recently, zinc oxide nanoparticles have been utilized as a fortified cold cream[5] Surface modification that enhances aggregation of these nanoparticles also affect their penetration as they effectively behave as larger particles. A recent study has shown that titanium dioxide nanoparticles have the potential to induce autophagy and necrosis in Sertoli cells in high doses and adversely affect spermatogenic cells and testicular morphology in Zebra fish.[6] Hence, the environmental exposure of titanium dioxide nanoparticles needs to be looked into. While there has been contrasting evidence, it is important to realize that the effect depends on the dose, size, route of administration and the barrier state of the skin or mucous membrane.

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Healthy human skin usually forms a barrier for the penetration of rigid, insoluble nanoparticles. However, the preconditioning of the skin may alter penetration of titanium dioxide nanoparticles. Mild skin damage from UV radiation can lead to enhanced penetration of titanium dioxide nanoparticles in the deeper layers of the stratum corneum. On the other hand, gold nanoparticles of 5 nm have been reported to diffuse through the intact stratum corneum barrier in animals.[7]

Another category of nanoparticles are those which are generally recognized as safe (GRAS) approved, biodegradable and are used primarily for encapsulation of actives. Many such nanocarriers have been used safely in cosmetics with enhancement of the effectiveness of the actives. Polycaprolactone nanocapsules have been used to enhance stability of actives, as well as have reduced the penetration and hence systemic adverse effects of sunscreen agents like benzophenone. Polycaprolactone encapsulation of lipoic acid has been reported to enhance its antioxidant effects due to stabilization as well as sustained release of actives.[8]

Another class of GRAS approved nanomaterials that find enormous applications in cosmetology are lipid based nanocarriers. These include liposomes, solid lipid nanoparticles, nanostructured lipid carriers and nanoemulsions. The main advantage of lipid based nanoparticles in cosmetology is their similarity with the lipid rich stratum corneum layer and the ability to self assemble in flexible nanostructures using bilayers of lipids. The unique brick and mortar arrangement of the corneocytes and the ceramide rich lipid matrix give the stratum corneum its barrier properties. Phospholipids and lipid based chemical enhancers are able to modulate the physical packing of the layers of the stratum corneum and influence the penetration of actives.[9] The composition, size and charge of the carriers can influence their topical residence and the depth of penetration in the skin.

The shape of the nanostructures can also influence the cellular response towards them. Nanofibers have also found applications in cosmetics. Cellulose nanofibers are one such platform. These include modified forms of cellulose nanofibers using oxidation processes, face masks using bacterial cellulose as well as cellulose nanofibers prepared from green algae for their viscosity enhancing properties.

Apart from the various depths of the epidermis and dermis, hair follicles are another site where nanoparticles applied topically commonly accumulate. The depth of penetration and access through the hair follicle shaft depends on the size and surface charge of the nanoparticles. This opens up the possibility of targeted delivery of actives to the hair follicles using suitably engineered nanoparticles. The pilosebaceous glands have recently been found to be an easily accessible route for penetration of nanoparticles through the skin.[10] The effect of massage and application also can alter the follicular penetration of nanoparticles. This opens up interesting applications in cases of hair oils, hair creams and hair dyes.

While the primary function of nanotechnology aided cosmetics focus on the improvements in the aesthetic appeal and acceptability to customers; recently many hybrid applications are emerging which utilize cosmetics as bases for additional health and well-being options. Nutricosmetics is one such platform which leverages the accessibility of cosmetics to aid in the regional delivery of nutritional agents. Nanotechnology can specifically aid in this function by enhancing the stability and half-life of otherwise labile vitamins and minerals, allowing enhanced effects locally. Cosmetics have been loaded with nanoparticles for delivery of folic acid, B12 and ferrous salts to enhance the baseline levels of these nutrients non-invasively.[11]

Another aspect of hybrid functionality is that of medicated cosmetics. These include options for acne, eczema, alopecia, to name a few, which are closely related to skin and its appendages and can benefit from the localized delivery of therapeutic agents within easy to use bases of oils, lotions, shampoos and nail polishes. Cosmetic fillers for reconstructive surgery are another example where nanostructured cosmetic materials can aid in both health and reconstruction. Nanotechnology can be useful in such cases to reduce the dose of active required, allow site specific controlled release and maintain the organoleptic properties of the base cosmetic.[12]

Keeping the vast number of nanotechnology associated cosmetic patents in mind, it is expected that the number of products utilizing nanotechnology in cosmetology will rise exponentially in the coming decades. This can have many beneficial effects provided one clearly understands the specific nature, cellular reactions, safety and implications of each type of nanoparticle utilized. Safe, responsible nanocosmetics can be tailor-made to enjoy the benefits of nanotechnology in cosmetology, while avoiding the toxicity and progressing towards enhanced health, beauty and wellbeing.

CONFLICTS OF INTEREST

The author declares holding patents in the area of nanoparticle loaded cosmetics.

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