Current Trends in Nanocosmeceuticals


Sakshi V. Khairnar & Sathish Dyawanapelly*

Department of Pharmaceutical Sciences and Technology, Institute of Chemical Technology, Matunga (E), Mumbai-400 019, Maharashtra, India

sa.dyawanapelly@ictmumbai.edu.in, sathishinpharm@gmail.com

Introduction

Nanotechnology demonstrates advancement in the field of science and technology by enhancing product efficacy via the introduction of novel alternatives. Nanotechnology, in general, is described as the application of science and engineering concepts to create and use extremely small materials (~1000 nm). Nanotechnology has been used in a variety of areas, including optical, biomedical, electronics, mechanical engineering, chemical engineering, and in products like food and cosmetics (1). Shape, size, crystallinity, surface properties (porosity, surface modifications, charge, coating weathering, area), agglomeration state, chemistry, biopersistence, and other factors that influence the bioactivity and biokinetics of nanoparticles (NPs) (2). In 2012 and 2015, sales of nanomaterials-containing products numbered about $155.8 billion and $2.6 billion, respectively, with projections to reach over $55.3 billion in 2022 (3).

Nanotechnology is increasingly being used in the field of cosmeceuticals to address some of the disadvantages associated with conventional products (4). Liposomes, niosomes, ethosomes, transferosomes, fullerenes, silver NPs, silica NPs, solid lipid NPs, and other nanomaterials used in cosmetics are only a few examples (5). Concerns about the safety of these nanocosmetics have recently surfaced, prompting the cosmetics industry to restrict the use of nanotechnology in cosmetics and to enforce regulations requiring comprehensive safety testing before entering the market. The traces of the application of nanotechnology in cosmetics can be found in Egypt 4000 years ago where the judicious blend of naturally available minerals with oils in lead-based chemistry, could contribute to the synthesis of lead sulfide nanocrystals. The dermal path is often a crucial route of exposure to cosmetic substance NPs. Nanotechnology is currently being used to improve three aspects of the cosmetics manufacturing process, including product development, packing, and equipment.

Nanomaterials have a large surface area, which makes them effective for ingredient transfer across the skin. The effective penetration into the skin for better absorption of the product's additives, new color components (e.g., nail and lipsticks products), clarity (e.g., in sunprotective agents), and the long-durable effects are some of the key goals of using nanomaterials in cosmetics (e.g., in makeup) (6). It enhances the stability of different cosmetic products encapsulated inside NPs, such as unsaturated fatty acids, enzymes, or antioxidants (figure 1). As a result, the beauty industry often employs nano-scale materials.

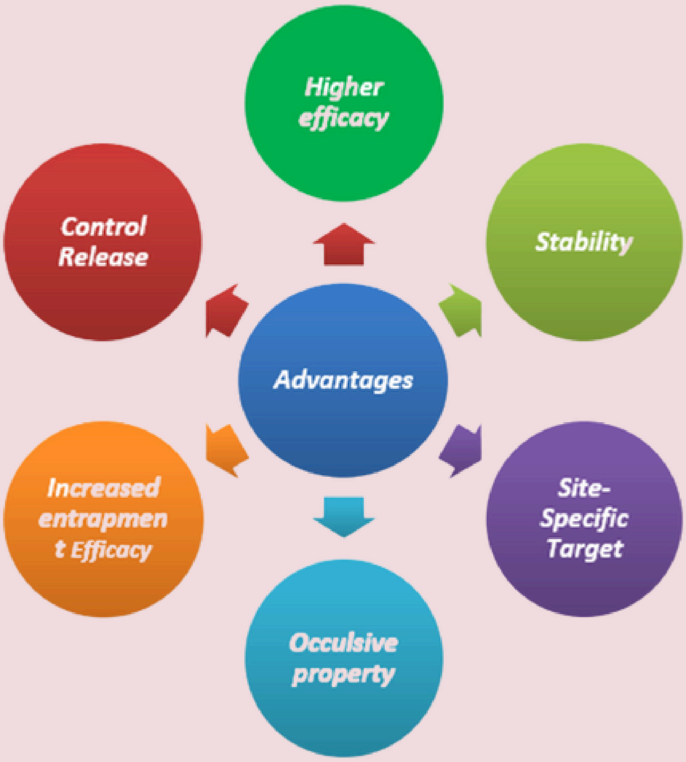

Figure 1: Advantages of Nanocosmeceuticals

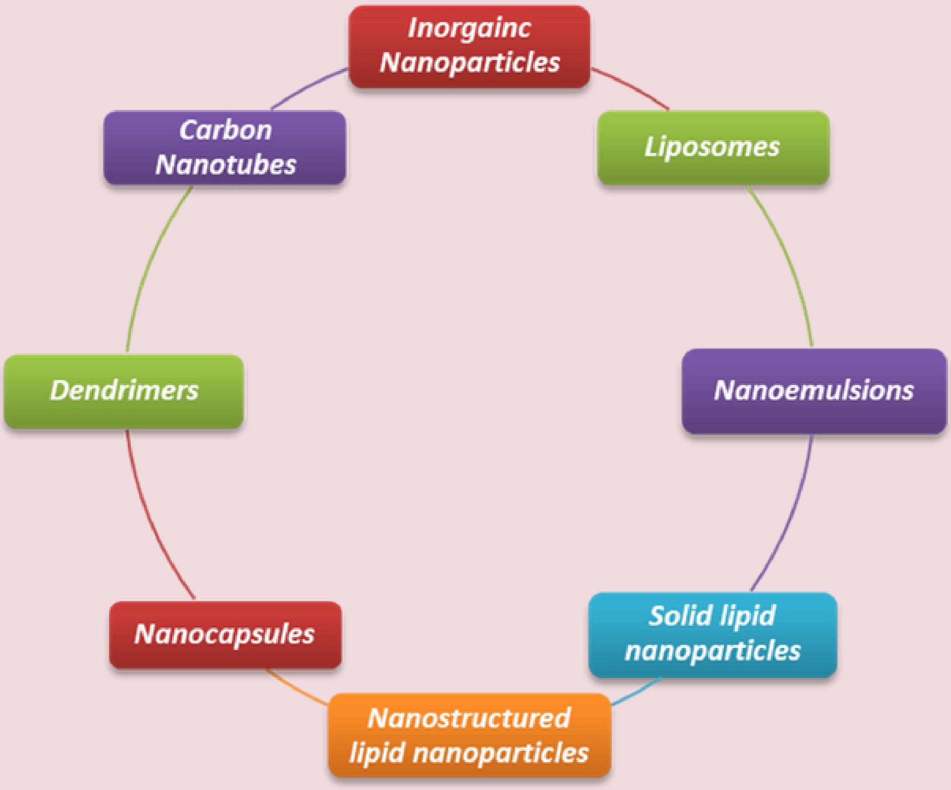

Figure 2: Various nanocarriers used in cosmeceuticals

Inorganic nanomaterials used in cosmetics

The various nanocarriers used in cosmeceuticals are given in figure 2. Inorganic NPs like titanium dioxide (TiO_2) and zinc oxide (ZnO) are used as ultraviolet (UV) filters (7). But it may absorb a lot of UV light, which results in hydroxyl species in aqueous media. These species can cause significant DNA damage, raising questions about sunscreen's overall effects. Nanogold has been used in an ‘energizing' moisturizer cream as well as a face mask, and nanosilver is used in certain personal care items due to its antibacterial properties (7). Silica NPs serve as an absorbent and anti-caking agent. Aluminum oxide NPs have a "soft focus" effect, which helps to hide wrinkles.

Organic materials used in cosmetics

The simplicity with which liposomes can be prepared and their ability to increase the absorption of active ingredients by the skin are two of the reasons for their extensive use in the cosmetic industry (8). They're in sunscreens, anti-aging, and moisturizing creams. Liposomes are even used in hair loss treatment. Phytosomes are used in sun-care products to cover sun-exposed skin by releasing a photoactive-enzyme derived from the Anacystinidulans marine plant. Transferosomes are more elastomeric and efficient than liposomes. It's a component of anti-wrinkle cream. Anti-wrinkle creams also contain ultrasome. It aids in the prevention of collagen and elastin production injury. Ethosomes are soft, malleable vesicles that help distribute active agents more effectively (9). Both Nanosomes and Fullersomes are used in skin creams for various reasons. The former is used to improve skin's wellbeing and youthful appearance, while the latter is used to refresh dark circles under the eyes. Anti-aging creams and moisturizers include carbon fullerene NPs. Fullerenes, also known as C-60, are spherical, cage-like molecules that are mostly made up of carbon atoms. Non-ionic surfactant vesicles are known as niosomes. These are vesicular mechanisms that can transport both amphiphilic and lipophilic drugs.

Nanoemulsions are uniformly dispersed nanoscale droplets of a liquid in another liquid. These droplets have a wide contact area with the skin and can serve as a carrier for active ingredients in cosmetics (10). These ingredients are considered safe for use in cosmetic formulations. Nanoemulsions have a smaller droplet size, which means they are more efficient and stable, as well as transparent. Nanoemulsions display exceptional promise in the near future of cosmetics. They are considered the most forward NP system in cosmeceuticals. Nanoemulsions are widely used in lotions, deodorants, nail enamels, sunscreens, conditioners, shampoos, and hair serums as a medium for controlled delivery.

The tiny size of *solid lipid nanoparticles (SLNs)* maintains direct contact with the stratum corneum, allowing for greater ingredient penetration into the skin (11). They can support the skin, retain more water while still acting as possible UV blockers. SLNs can increase chemical stability and Nanostructured lipid carriers (NLCs) can hold many active ingredients. Moisturizing creams and sunscreens tend to involve SLNs and NLCs (11). Polymeric capsules encased in an oily or water phase are known as nanocapsules. Polymeric nanocapsule suspensions can be used as a direct substance on the skin or even as an ingredient in semisolid preparations.

Dendrimers have a spherical architecture that consists of a center on which symmetric units are formed, and this arrangement is what gives them their flexibility. In shampoos and deodorants, dendrimers are used. Long-lasting hair dyes with carbon nanotubes provides smoothing, anti-damaging and volumizing effects and hydroxyapatite NPs provides good polishing effect while maintaining long-lasting tooth remineralization. Some of the commercial cosmeceutical products with nanomaterials are listed in figure 3.

Figure 3: Commercial nanocosmeceutical products

Toxicity issues

Concern has been raised about the possible risks that may arise from NP interaction with human skin. It is essential to understand how deep a NP can go through the skin. The effects of NPs on mammalian cells have been studied both in vitro and in vivo. The phototoxicity, genotoxicity, photo-genotoxicity, and carcinogenicity of various nanomaterials, as well as their ability to pass through or through the skin, is very well known (12). Titanium dioxide NPs, one of the most widely used topical additives causes brain damage and decreased sperm output in male off-spring, according to recent research. Aluminum oxide and iron oxide NPs had shown in vitro cell toxicity with nanocosmeceuticals.

Identifying how a nanomaterial's physicochemical properties affect its tendency to infiltrate the skin enables researchers to engineer the nanomaterial to prevent it from causing damage to skin cells or going through the dermis and then into the bloodstream. It is widely agreed that the use of NPs in cosmetics must be assessed on a case-by-case basis, taking into consideration parameters such as size, shape, concentration, distribution, as well as the physical and chemical properties of the nanomaterials used and their interactions with cells. Similarly, the impact of accumulation in some parts of the body, such as the liver, or after prolonged exposure are important factors to consider. Nanomaterial exposure in the workplace may occur during the manufacturing process, by-products containing these substances, or during the processing, disposal, or recycling of these goods. Nanomaterials have much higher toxicity than micronized particles, owing to their greater ability to penetrate tissues and living cells. Nanomaterials often pose a threat to the environment. Where enough nanomaterials are released into the air, water or soil during their manufacturing, usage, or disposal, they can cause environmental problems.

Concerns governing the safety of nanomaterials and their utilization in consumer products have been identified by the World Health Organization, non-governmental bodies, political authorities, and agencies. The European Union Observatory for Nanomaterials declared at the beginning of 2020 that all industries that produce use or import nanoforms must have a REACH registration (Registration, Evaluation, Authorization, and Restriction of Chemicals), which is a Regulation of the European Union (13).

Future perspective and conclusion

It is undeniable that nanotechnology could support cosmetics and personal care products by enhancing their efficiency. However, alongside their immense scientific and economic promise, a discussion about nanotechnology threats has begun. As a result, more research is required, as well as detailed knowledge for customers about the use of nanomaterials in cosmetic products in general. The expanded ability of NPs to infiltrate the skin and obtain access to human cells is a double-edged sword: it could be beneficial for medicinal reasons, but it may also lead to much greater absorption of compounds that are harmful to human health. The issue of nanotechnology's safety, as with any new technology, is critical. The many details that must be considered are generally too technical for the ordinary person to comprehend

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