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Nanoparticles in cosmetics, what we don't know about safety and hidden risks. A mini review

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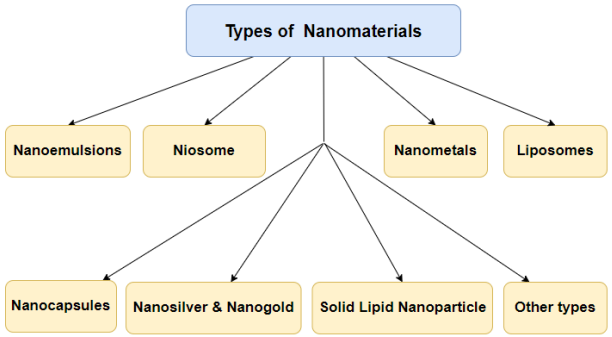
Graphical abstract



Abstract

Nanotechnology exemplifies advancement in the field of research and development by enhancing product efficacy through the introduction of novel solutions. Nanotechnology is increasingly being used in the cosmeceutical industry to address some of the drawbacks of traditional products. The personal care market's fastest-growing segment is cosmetics, and usage of these products has increased dramatically in recent years. Wrinkles, photoaging, hyperpigmentation, dandruff, and hair damage can all be treated using nanocosmeceuticals, a class of skin, hair, nail, and lip care products. However, because nanoparticles have the ability to penetrate skin and cause health issues, nanotoxicological studies have raised questions regarding the impact of increasing nanoparticle use in cosmeceuticals. The study of nanotechnology in cosmeceuticals is primarily concerned with the many special carriers used for cosmeceutical administration, their benefits and drawbacks, commercial formulations, toxicity, and nanocosmeceutical limitations. This editorial's main objective is to illustrate the benefits and drawbacks of using nanoparticles in cosmetics.

Keywords: Nanocosmetics, nanoparticles, saftyhealth.

1. Introduction

Nanotechnology is frequently cited as the most significant technical development of the twenty-first century and is expected to have a significant impact on the cosmetics market. The term "nanotechnology" is formed up of the terms "technology" and the Greek digit "nano," which signifies "dwarf." As a result, the science and technology used to create or work with particles with dimensions ranging from one to 100 nanometers are referred to as nanotechnology (Logothetidis, 2012; Maynard, 2006). Since its entrance to the cosmetics, health care, and dermatological preparations sectors in 1959, nanotechnology has been employed in a wide range of industries. It is a blend of engineering, physics, chemistry, biology, and science. The Egyptians, Greeks, and Romans all asserted the usage of nanotechnology throughout the 4000 BC era, including the concept of nanotechnology-based hair color preparation (Bangale *et al.*, 2012). The cosmetics industry has embraced nanotechnology through its producers and researchers, and it is discreetly but slowly broadening its boundaries to satisfy consumers' growing need to seem attractive and youthful. Nanoform particles used in cosmetics include dendrimers, cubosomes, and nanoemulsions. Examples of nanoscale goods include sunscreens, anti-aging treatments, razors, and curling tongs (Raj *et al.*, 2012).

Nanomaterials have been used to make cosmetics since hundreds of years ago. Silver and gold nanoparticles have been used by women as nail colors. In the Middle Ages, anti-aging liquid formulations using gold nanoparticles were also used. However, in recent years, the use of nanoscaled materials in the manufacturing of cosmetics has increased significantly (Raj *et al.*, 2012). The types of nanomaterials utilized in cosmetics by the major cosmetic businesses, as well as any possible concerns they pose to both human life and the environment, are highlighted in this review.

2. Cosmetics and nanocosmetics

An adult utilizes nine cosmetic items on average every day (Bangale *et al.*, 2012). Cosmetics are without a doubt among the items that are used the most frequently in the world. Their ability to satisfy a man's innate need to

appear well and maintain young is what makes them so alluring. The Roman playwright Plautus once said, "A lady without paint (cosmetics) is like food without salt." What a powerful method to convey the significance of cosmetics! Since ancient times, people have utilized cosmetics and related substances for anything from boosting self-confidence to enhancing attractiveness (Gautam and Vijayaraghavan, 2011). Cosmetics, with the exception of soap, are defined by the Food and Drugs Act (FDA) of the United States of America as any product or article that is intended to be rubbed, poured, sprinkled, sprayed, introduced into, or otherwise applied to the human body or a part of it for cleaning, beautifying, promoting attractiveness, or changing the appearance (USA) (Sharma, 2012).

Cosmetics are a broad category that includes a variety of personal care items. Cosmetics are classed as

1) skin-care cosmetics (e.g. cleaning agents, moisturizing agents).

2) hair-care cosmetics (e.g. styling agents, hair colorants, shampoos) depending on the body areas to which they are applied.

3) Cosmetics for the face, such as lipsticks, powders, mascara and foundations for the face.

4) Nail-care items, such as paint removers and nail polish removers.

5) Fragrance goods, such as aftershaves, deodorants, cologne, and perfumes.

6) UV light screening preparations, such as sunscreens.

According to this concept, cosmetics are obviously not medicines. On the other hand, certain cosmetic items are referred to as "cosmeceutical" goods because they may contain ingredients that have a biological effect, moderate therapeutic action, or drug-like benefits on the skin (Dureja *et al.*, 2005). This term has been used by skin scientists, skin care specialists, doctors, product manufacturers, and even authors in academic or cosmetic papers to promote consumer endorsement of promoted cosmetic products and identify cosmetics. On the other hand, this article interchangeably uses the phrases cosmeceutical and cosmetics. Cosmetics using nanosized components are known as nanocosmeceuticals. Numerous nanocosmeceuticals are used in nail, hair, lip, and skin care products. The main subcategories of nanocosmeceuticals are shown in Table 1.

Table 1. Main classes of nanocosmeceuticals.

Nanocosmeceutical					
Sun screen	**Hair care**	**Lip care**	**Nail care**	**skin-care**	**Fragrance goods**
'Skin care'	'Hair serum'	'Lip balm'	'Nail polish'	'cleaning agents'	'Deodorants'
'Moisturizer'	'Shampoo'	'Lip gloss'	'Nail polish remover'	'moisturizing agents'	'Aftershaves'
'Antiaging products'	'Hair color'	'Lip volumizer'			'Cologne'
'Skin cleanser'	'Conditioner'	'Lipstick'			'Perfumes'
'Eye cream'	'Hair growth stimulators'				
'Antiacne products'	'Hair styling gel'				

3. Types of nanomaterials that used in cosmetics

Nanomaterials are substances with at least one dimension in the nanometer range with noticeably unique physicochemical characteristics. The cosmetics industry has long employed these ingredients on a regular basis. In comparison to microscale cosmetics, those that use nanomaterials exhibit greater benefits. These particles' vast surface areas are what allow for effective absorption, bioavailability, and transparency as well as the product's long-lasting effects. To avoid the related toxicity, care should be paid to the concentration. Table 2 below lists some nanomaterials utilized in the cosmetics sector (Fytianos *et al.*, 2020; Pandey and Dahiya, 2016; Saxena and Chandra, 2011; Mohapatra *et al.*, 2021; Lee *et al.*, 2019; Nguyen and Rajendran, 2020; Alaqad and Saleh, 2016; Lamberti *et al.*, 2014).

Cosmetic nanomaterials come in a wide variety of shapes and sizes, and each one has a special set of characteristics that determines the type of cosmetics they are most suited for (Mukta and Adam, 2010). Here are a handful of them, together with their components, attributes, and applications, as shown in Figure 1.

3.1. Liposomes

Liposomes are bilayer vesicles used in the cosmetics industry that are safe and predominantly formed of natural or semisynthetic phospholipids. By adhering to the bilayer structures of the skin, liposomes offer a lot of benefits when it comes to delivering cosmetic active ingredients to biologic cells, such as vitamins, antioxidants, minerals, and anti-aging substances. Transferosomes, niosomes, and ethosomes are a few examples of vesicles with improved skin penetration (Cevc).

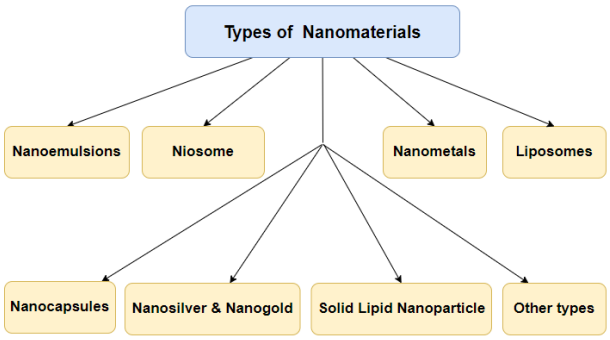


Figure 1. Nanocarriers for cosmeceuticals.

3.2. Nanometals

Nanometals like nanosilver and nanogold have been utilized in toothpastes and deodorants because of their great efficacy and antibacterial properties. These materials have a high market value among nanoparticles because they are widely used in a number of applications in a variety of industries (Song and Liu, 2005).

3.3. Solid lipid nanoparticles

Solid lipid nanoparticles are nanoscale lipid droplets stabilized with surfactants containing active ingredients (SLNs). These nanostructures are capable of protecting the encapsulating active compounds from deterioration. SLNs may also be used to boost the skin penetration of active ingredients in cosmetics and to design cosmetics with controlled distribution. SLNs have been shown to offer additional advantages, such as (Shokri, 2017):

(a) better skin hydration from cosmetics.

(b) Some chemical sunscreen active ingredients have increased the effectiveness of their sunscreen.

3.4. Nanoemulsions

Nanoemulsions are droplets of one liquid that are evenly dispersed in another liquid at the nanoscale. These droplets can serve as carriers for active ingredients in cosmetic products since they have a large surface area that comes into contact with the skin. These components are regarded as secure for use in the production of cosmetics. As a result of their minuscule droplet size, nanoemulsions are more effective, stable, and transparent (Jothy *et al.*, 2015).

3.5. Nanocapsules

Aqueous or oily phase arenanstructures constructed of polymeric materials are called nanocapsules. Because they are extremely sensitive, some active substances, such vitamin D or potent cosmetic active compounds, are believed to be excellent carriers in these formulations (Gajbhiye and Sakharwade, 2016).

3.6. Niosome

It serves as a colloidal vesicular carrier for medication delivery. It includes non-ionic surfactant vesicles that are biodegradable and safe. It is less costly and more stable than other colloid carriers. It may be utilized for controlled and precise drug administration in novel pharmacological formulations such as oral, topical, parental, and oral. In the 1970s, niosomes were used for the first time in the cosmetics sector. Niosomal lotion was launched by Lancome in 1986 to fight the signs of aging. It may be used to cure cancer, provide hemoglobin, deliver peptide drugs orally, treat leishmaniasis, transport medications to the eyes, make cosmetics, and act as a carrier for cutaneous drug delivery in cutting-edge drug delivery. This review study covers niosomes' structure, composition, advantages, types, production processes, characterization, and usage. In-depth discussion is also given to the niosome's function as a carrier in the application of cutaneous medications (Gajbhiye and Sakharwade, 2016).

3.7. Nanosilver and Nanogold

Nanosilver makes about 12% of all nanosized particles used in cosmetics throughout the world (Kheybari *et al.*, 2010). Mineral nanoparticles are metallic nanoparticles with a size of less than 100 nanometers. Applications and characteristics: silver nanoparticles, also known as nano silver or colloidal silver, have been used as preservatives in a range of personal care products, such as toothpaste, shampoos, and acne treatments. This has to do with the antibacterial properties of silver nanoparticles. Silver nanoparticles have been shown to be resistant to Staphylococcus epididermis, E. coli, Pseudomonas aeruginosa, Vibrio cholera, Staphylococcus aureus, and Syphilis typhus, making them promising anti-infective drugs (Morones *et al.*, 2005; Mukherji *et al.*, 2012). According to published literature, silver nanoparticles' antimicrobial action is due to the release of silver ions, and similar research on nanosilver and its derivatives has been conducted extensively to harness its unique antibacterial and antifungal characteristics (Mukherji *et al.*, 2012). However, due to their unique properties for delivering and unloading drugs as well as their ease of production, gold nanoparticles might be employed in cosmetics. They are often readily functionalized, often by thiol linkages, and can be combined with aesthetic components to boost the end product's quality. According to reports, nano gold has been incorporated to toothpastes and other commercially accessible personal care products, resulting in effective dental hygiene (Robertson *et al.*, 2010).

Table 2. Several nanomaterials are employed in the preparation of cosmetics and coseceuticals.

S. No.	Nanomaterial	Advantage	Disadvantage	Uniqueness	Type of Cosmeceutical	Commercially Available Product
1.	Inorganic particles (TiO_2, ZnO)	Hydrophilic, biocompatible, safe, and stable	Pulmonary toxicity	Absorb/reflect UV light	Sunscreen	Phytorx UV Defense Sun Block SPF 100—Lotus Professionals
2.	Silica (SiO_2)	Hydrophilic, ↓ manufacturing cost	Pulmonary toxicity	Used as filler to ↑ the bulk of the cosmetic formulation	Lipstick	Face FWD >> Blush Stick—Sugar Cosmetics
3.	Carbon black	Light weight, ↑ chemical and thermal stability, and ↓ cost	Cytotoxicity; alters the phagocytic property of macrophages	Color pigment	Facemask	Face Masque —Carbon BAE
					Mascara	Mascara Black—Lakme
4.	Nano-organic (tris-biphenyl triazine)	Powerful and photostable filter	Hazardous to the aquatic environment	Most efficient UVB and UVA 2 filter	Sunscreen	Extra UV Gel—Allie
5.	Nano-hydroxyapatite	Dental desensitizer and polish remineralization of teeth	Very brittle nature	Safe in pediatric toothpaste	Toothpaste	Kinder Karex Hydroxyapatite
						APAGARD M plus—Sangi
6.	Gold and silver nanoparticles	Uniform shape, size, and branch length; tuned pharmacokinetics and biodistribution; antibacterial and antifungal activity; and chemical stability	Damages human cells and DNA at high doses; pulmonary toxicity	Surface-enhanced Raman scattering	Facemask	Gold Radiance Peel Off Mask-VLCC
					Anti-aging cream	Nano Gold Firming Treatment—Chantecaille
7.	Buckyballs (buckminster-fullerene/C60)	Exhibits antioxidant activity, thermostability, and photostability; prevents many skin problems related to oxidative stress	Pulmonary toxicity; damages brain tissues; highly hydrophobic	Potent scavenger of free radicals	Face cream	Brightening Essence—Juva Skincare

3.8. Other types of nanocosmetics

Nanocrystals, dendrimers, cubosomes, hydrogels, and buckyballs are just a few of the numerous nanostructures that have been employed in cosmetic formulations. The shape, surface area, functional groups, and capability of nanoparticles to skin penetration.

3.9. Cosmetic benefits, safety and health concerns

The peculiar properties of nanoparticles used in cosmetics might be a double-edged sword. On the one hand, it offers alluring cosmetic benefits, but on the other hand, it

could have a negative impact on the body's systems. Because established particle properties may quickly change at the nanoscale, this poses safety and health problems. The toxicity of nanomaterials is similarly unknown. As a result, the biggest safety concern with nanosized particles in cosmetics is whether or not they can enter the bloodstream during manufacture or during usage. What negative consequences can they have if they do? The need for nanomaterials safety was brought to the forefront in the United States when the FDA's nanotechnology theories issued to suggest for regulatory consideration, with a focus on cosmetic item safety and non-adulteration (Banerjee, 2017). The FDA requires two primary pieces of information (strategies) to assess the safety of nanoparticles in cosmetics. One is information about the properties of the substance, particularly the nano-form in which it was used. Information on such materials, as well as finished cosmetic products, will contain these attributes, as well as biological interactions and the characterisation of any related contaminants, because nanoparticles can have a variety of physicochemical properties. With such exact and easily accessible information, poisoning, pollution, and allergy issues may all be treated more successfully. The second component of this information is the toxicological data for the nano-sized product. Cosmetic chemicals should be evaluated for acute, chronic, and sub-chronic systemic toxicity, skin irritation and allergy, photo irritation and photoallergy, as well as for acute, chronic, and sub-chronic systemic toxicity. Accumulated of nanoparticles exposure to comparable items or continuous usage of certain products has a toxicological risk. Genotoxicity, fetal toxicity, carcinogenicity assessment, and reproductive health effects will be among the additional data required. Nanocosmeceuticals have some disadvantages as in Figure 2:

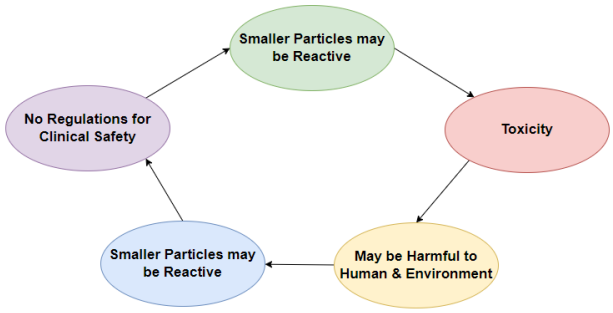


Figure 2. Nanocosmeceuticals disadvantages.

3.10. Dangerous of using nanomaterials in cosmetics

Numerous researchers have found evidence of unwanted nanoparticle penetration into the skin and systemic circulation. It has been demonstrated that sunscreen creams containing titanium dioxide, zinc oxide, and other nanoparticles with sizes ranging from 10 to 200 nm can accidentally penetrate intact skin and injure living tissue. Zinc oxide nanoparticles were found to be neurotoxic in in vitro experiments using mouse neural stem cells (NSCs). Additionally, several researches have found that the cytotoxicity of titanium dioxide nanoparticles. In current research, titanium dioxide nanoparticles were shown to increase autophagy and necrosis in sertoli cells while also having a detrimental impact on spermatogenic cells and testicular morphology in Zebra fish. The penetration of these nanoparticles into the skin's deeper, more viable layers as well as general circulation are all enhanced by eczema, acne, wounds, psoriasis, and UV exposure. Workplace exposure to nanoparticles can occur throughout the production process, when using, recycling, or disposing of items that include nanoscale entities. Due to their higher capacity to enter tissues and living cells, nanomaterials are far more dangerous than micronized particles.

The three main ways that people are exposed to nanomaterials are by inhalation, ingestion, and cutaneous absorption. Nanomaterials are also linked to environmental problems. Environmental issues may arise if nanomaterials are manufactured, used, or disposed of in large amounts that are discharged into the atmosphere, water, or soil. Antibacterial nanoparticles, for instance, can interfere with the beneficial bacterial system of the natural ecosystem. Some nanomaterials have the ability to bind to airborne pollutants like cadmium or petrochemicals and transport them over long distances. Finally, all of these issues need to be taken into consideration when it comes to the creation, use, and disposal of nanocosmetics (Shokri, 2017).

4. Conclusion

Nanotechnology is a highly developed branch of science where nanoparticles are used because of their special capabilities in the cosmetics sector. As is common knowledge, there are many products on the market that contain nanoparticles in some way. In order to determine the toxicity of these particles, which is still a subject of much debate and ambiguity, we must study many of these materials and document their health effects, particularly when applied to the skin. All nanoparticles used in the creation of cosmetics must first undergo a practical application test before being approved for use. Following this test, the safe ingredients that can be used in the creation of these cosmetics must also be approved, along with proper product labeling and control of their effects. Additionally, users who use nanoparticle-containing cosmetics must report any odd interactions they have right away to the appropriate authorities in order for the market's safe goods to be monitored and supervised for health safety.

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