Assessment of Nanotechnological Advancements in Cosmetics: A Review

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ABSTRACT

Nanotechnology is being used in the cosmetics industry to develop diagnostic and therapeutic products, offering improved product characteristics such as enhanced skin penetration, anti-aging impact, and UV protection. However, the use of nanomaterials in cosmetics raises concerns about their safety and potential health hazards. To address these concerns, regulatory bodies are coordinating methodologies and identifying the types of nanomaterials used, their stability, and exposure routes. This article aims to increase consumers' and regulators' awareness of the benefits and potential toxicity associated with the continuous and prolonged use of these products.

Introduction

Today, the importance of cosmetic products has shifted to nutritional and therapeutic products that improve skin health and advance the treatment of dermatological disorders. With such, innovative technology enabled the utilization of nanoparticles. The advent of a unique lipid-based nanoparticulate technology has led to the rapid launch of novel cosmetic items in a very dynamic cosmetic sector (Ahmad, J., 2021). Additionally, the application and adoption of nanotechnology-based methods are recognized as one of the hottest technologies currently accessible due to better product characteristics. Because of their small size and high surface area-to-volume ratio, nano-scale substances are becoming more and more desirable for usage in cosmetic products (Bilal, M. and Iqbal, H., 2020).

There is a growing trend of males purchasing cosmetics which underscores the need for further investigation into observed gender differences in security, knowledge, satisfaction, and importance of cosmetics, emphasizing recent advancements and the consideration of male physiology in the field (Liu, W.Y. et al., 2012). Nanotechnology in cosmetics offers great potential for enhancing cosmetics through atomic-level material manipulation. It enables improved attributes such as scent release, color, UV protection, skin penetration, finish quality, and anti-aging effects. However, safety and security concerns arise, which can be addressed by identifying nanomaterials used and their stability, absorption potential, exposure route, and formulation in cosmetic products (Katz, L.M., Dewan, K., Bronaugh, R.L., 2015). Worldwide efforts are underway to establish methodologies and address definitional challenges and safety issues related to the use of nanoparticles in cosmetics (Raj, S. et al). The following indicates the most popular companies and ingredients.
Through keyword searches across multiple sources, this review study aims to provide an overview of nanotechnology-based cosmeceuticals, including ingredient descriptions, application areas, health and environmental concerns, regulatory measures, and their importance for safe and effective usage.

Methodology

The review is completed with the use of journal databases such as Pubmed, Elsevier, ScienceDirect, Research Gate, and MDPI. Well-structured arrangements of relevant phrases for database searches were applied without the intent to use for limitations which include conjunctions that may disrupt effective data gathering. Likewise, keywords used were: nanotechnology; nanomaterial; cosmetics; cosmeceuticals; nanocosmetics; nano cosmeceuticals; patent; regulation; health hazards; toxicity. A descriptive approach is exploited throughout the review as it emphasizes the general principles of these keywords. Comparative and narrative analysis was used in conjunction as well to further provide resolution to the concepts.

Results and Discussions

1. The Use of Nanomaterials in Cosmetic Products

This section tackles striking a balance between utilizing nanotechnology's potential and guaranteeing the safety of these substances, which calls for adherence to laws and continual investigation into their possible drawbacks and advantages.

Inorganic Particles

Among the commonly used inorganic nanomaterials used in cosmetics today include UV Filters (Titanium Dioxide and Zinc Oxide), Antimicrobials (Gold and Silver nanomaterials) Silica nanoparticles, Nano-Hydroxyapatite, Carbon black/Carbon-based nanoparticles, Nano-Organic (Tris-Biphenyl Triazine), and Bucky Balls (Buckminsterfullerene/C60). Table 1 presents the summary of their respective uses.

2. Nano-Delivery System in Cosmetic Products

Nanotechnology has recently addressed a number of issues in the medical and pharmaceutical fields. A similar idea has been used in cosmetics, leading to unique formulations known as nano cosmeceuticals that offer specialized treatments for cosmeceutical issues. A smaller size may be responsible for the innovative advantages as it aids in the development of new features such as improved solubility, transparency, chemical reactivity, and stability. Liposomes, ethosomes, solid lipid nanoparticles, nanocapsules, dendrimers, nanocrystals, cubosomes, and nanoemulsions are a few examples of the various nanomaterials employed in the cosmetics business. Nanoscience-based cosmetic compositions are widely sold nowadays (Gupta et al., 2022).
Through time, delivery of cosmetic ingredients incorporating nanotechnology has evolved; hence, various nanoformulations have been created, as seen in Figure 1. While they may share a common principle of nanodelivery, each of these nanoformulations has various advantages in its application as shown in Table 2.

3. Risks to Health from Nano Cosmeceuticals

Nanoparticles have a wide range of uses, including anti-aging products, cosmetics, nail care, and more (Santos, A. C., et al., 2019). However, nanoparticles pose health risks due to their potential toxicity, which is influenced by factors such as quantity, route, time of exposure, shape, surface structure, surface charge, chemical composition, and solubility. The alterations induced in nanoparticles can lead to either favorable or unfavorable outcomes, resulting in heightened reactivity but reduced stability (Xu et al., 2018). Moreover, nanomaterials can induce toxicity in various human systems and have endocrine-disrupting or immunological effects. These nanomaterials may cause immune responses that cause side effects or treatment failure. To ensure optimal and safe medical use, nano-imaging materials must be thoroughly evaluated for immunological effects and safety before clinical use (Li et al., 2022). The three routes of entry into the body are inhalation, ingestion, and through the skin. Inhalation is the most common route of exposure to airborne nanoparticles. According to Bierkandt et al., 2018, there are three main areas as potential sources of inhalation exposure in humans: the workplace, consumer products, and the environment. Accidental consumption of nanoparticles through hands-to-mouth transmission of food could have a mild negative effect, while intentional ingestion could have substantial negative effects after being absorbed by various body areas and eventually causing organ damage (Ansari et al., 2022). Furthermore, maternal exposure to nanoparticles during pregnancy can cause various adverse effects in the offspring, such as gestational problems, neurotoxicity, reproductive toxicity, immunotoxicity, and respiratory toxicity. Oxidative stress, inflammation, DNA damage, apoptosis, and autophagy are the main mechanisms underlying nanoparticle-induced fetotoxicity (Teng et al., 2021).

4. Risks to the Environment from Nano Cosmeceuticals

This section essentially is the provision on the harmful effects of Nanotechnology on the environment. This underlines the potency of nanotechnological substances on plants, animals, and other ecological organisms.

5. Cosmeceuticals and Cosmetics Regulatory Guideline

The section presents the different sets of regulatory guidelines with regards on the handling or management of nanotechnological substances in the cosmeceutical industry. On the latter part of this section is a comparative analysis on different countries, establishing thematics with regards to regulatory guidelines.
**Table 1: Summary of the use of Nanomaterials in Cosmetic Products**

<table>
<thead>
<tr>
<th>Nanomaterials</th>
<th>Advantages</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV Filters (Titanium Dioxide and Zinc Oxide)</td>
<td>Titanium dioxide, a white powder, is a non-toxic, safe, and well-tolerated UV filter in cosmetics.</td>
<td>Berger, M. (2012)</td>
</tr>
<tr>
<td>Antimicrobials (Gold and Silver nanomaterials)</td>
<td>Silver and silver-based combinations in cosmetics control bacterial growth and stabilize formulations for more than a year.</td>
<td>Gupta, V. et al., (2022).</td>
</tr>
<tr>
<td>Nano-Hydroxyapatite</td>
<td>Nano-hydroxyapatite is a promising new material for restorative and preventative dentistry, with strong remineralizing effects and favorable results on tooth sensitivity.</td>
<td>Pepla, E. (2014)</td>
</tr>
<tr>
<td>Carbon black/Carbon-based nanoparticles</td>
<td>Carbon black is a highly effective black pigment that can be used in cosmetics to provide a rich, vivid black color and UV protection.</td>
<td>Yaroshchuk, A. E. et al.,(2015).</td>
</tr>
<tr>
<td>Nano-Organic (Tris-Biphenyl Triazine)</td>
<td>It is a nanoparticle (size 100 nm) used in sunscreens and skin care products for its powerful benefits in sun protection.</td>
<td>Couteau, C. et al.,(2015)</td>
</tr>
<tr>
<td>Bucky Balls (Buckminsterfullerene/ C60)</td>
<td>Buckminsterfullerene is a powerful antioxidant that can protect skin from oxidative stress caused by free radicals and UV exposure.</td>
<td>Lens, M. (2009)</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Biodegradable nanoparticles (made of chitosan, lipids, etc.) ; non-biodegradable nanoparticles (ZnO, silica-based nanoparticles, etc. Chitin nanofibrils extracted from shellfish exoskeletons can form a hygroscopic subatomic protective layer that increases skin hydration.</td>
<td>Singh, T.G. et al.,(2016)</td>
</tr>
</tbody>
</table>

**Table 2: List of advantages of various nanoformulations**

<table>
<thead>
<tr>
<th>Nano formulation</th>
<th>Advantages</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nanoliposomes can effectively transport flavors, nutrients, and antimicrobial agents to enhance sensory attributes and extend the shelf life of food items.</td>
<td>Mozafari et al., 2008.</td>
</tr>
<tr>
<td></td>
<td>Nanoliposomes are attractive “smart” drug delivery systems due to their scalable production using natural, affordable ingredients, as well as their biocompatibility and biodegradability.</td>
<td>Demirci et al., (2017)</td>
</tr>
<tr>
<td></td>
<td>Niosomes offer versatile drug transport capabilities with various configurations like proniosomes, disomes, and aspasomes.</td>
<td>Sepideh, K., Morteza, Y., (2017)</td>
</tr>
<tr>
<td></td>
<td>Due to their amphiphilic structure, it offers a broad range of solubility for drug molecules.</td>
<td>Madhav NV, Saini A (2011).</td>
</tr>
<tr>
<td>Sphingosomes</td>
<td>Restore the skin's barrier function and repair dry and damaged skin</td>
<td>Kusuma Priya, M.D. et al. (2020)</td>
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<tr>
<td>---</td>
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</tr>
<tr>
<td>Solid lipid nanoparticles (SLNs)</td>
<td>In comparison to formulations that are typically used, it reduces the amount of sunscreen agent that is required while still providing the same level of protection.</td>
<td>Fytianos, G., Rahdar, A. and Kyzas, G.Z. (2020)</td>
</tr>
<tr>
<td></td>
<td>Using biodegradable physiological lipids reduces the risk of acute and long-term toxicity and avoiding organic solvents in production processes.</td>
<td>Rupenagunta, A., et. al. (2011)</td>
</tr>
<tr>
<td></td>
<td>Solid lipid nanoparticle-based sunscreens may function as permeation enhancers, which increases the active moiety's tolerance and penetration.</td>
<td>Jose, J., &amp; Netto, G. (2019)</td>
</tr>
<tr>
<td></td>
<td>It exhibits UV-blocking properties, which implies that it has the ability to function as physical sunscreens on its own and can be used in combination with molecular sunscreens to enhance photoprotection.</td>
<td>Wissing, S.A., and Müller, R.H.</td>
</tr>
<tr>
<td></td>
<td>It function as occlusives, which indicates that they can be utilized to increase the skin's water content.</td>
<td>Wissing, S.A., Lippacher, A., Müller, R.H., 2001</td>
</tr>
<tr>
<td>Nanostructured lipid carriers (NLCs)</td>
<td>It has occlusive properties, hence, reduces transepidermal water loss (TEWL) leading to an increase in skin hydration.</td>
<td>Dubey, A., Prabhu, P., &amp; Kamath, J. V. (2012)</td>
</tr>
<tr>
<td></td>
<td>Compared to conventional products, it has a higher increase in hydration and elasticity of the skin.</td>
<td>Müller, R.H. et al. (2007)</td>
</tr>
<tr>
<td></td>
<td>Encapsulating inorganic sunscreens in NLC, is a potential method to produce well-tolerated sunscreens with high SPF.</td>
<td>Dubey, A., Prabhu, P., &amp; Kamath, J. V. (2012)</td>
</tr>
<tr>
<td></td>
<td>Due to the scattering of UV radiation caused by their particulate character, they are protective like titanium dioxide.</td>
<td>Samimi S., Maghsoudinia N., Eftekhari R.B., Dorkoosh F. (2021)</td>
</tr>
<tr>
<td>It has a long shelf life which may provide ease to large-scale production.</td>
<td>Fytianos, G., Rahdar, A. &amp; Kyzas, G.Z. (2020)</td>
<td></td>
</tr>
</tbody>
</table>
When compared to other delivery methods, it is more affordable.


<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Nanocrystal</td>
<td>High drug solubility, particle distribution, adhesiveness, dissolution rate, skin penetration of poorly water-soluble drugs</td>
<td>Nguyen, T.A. and Rajendran, S. (2020)</td>
</tr>
</tbody>
</table>

**Table 3: Summary of nanoparticles that are a risk to health.**

<table>
<thead>
<tr>
<th>Nanoparticles</th>
<th>Risk to Health</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZnO (Zinc oxide)</td>
<td>ZnO nanoparticles exhibit various toxicities, including mutagenicity, pulmonary toxicity, and cytotoxicity, with effects dependent on concentration, target tissue, route of exposure, and duration; while damaged skin and nasal exposure pose risks.</td>
<td>Keerthana, S., &amp; Kumar, A. (2020) Frober et al. (2020);</td>
</tr>
<tr>
<td>AgNP (Silver nanoparticle)</td>
<td>Silver nanoparticles (AgNPs) entering the respiratory system through inhalation impair the alveolar-capillary membrane, inhibit cardiac ion channels, and disrupt the endoplasmic reticulum, affecting liver metabolism and organ functionality.</td>
<td>Ferdous &amp; Abderrahim Nemmar (2020) Lin, C. (2017) Al-Doaiss, A. et al. (2020)</td>
</tr>
<tr>
<td>Carbon Black nanoparticles</td>
<td>Inhaled carbon black can activate endothelial cells, cause genomic instability, increase systemic inflammation mediated by TNF-α, and pose respiratory and cardiovascular health risks, including asthma, lung cancer, oxidative stress, inflammation, and DNA damage in lung cells.</td>
<td>Tang et al. (2020) Li, N., et al. (2002) Li, R. et al. (2014)</td>
</tr>
</tbody>
</table>

**Table 4: Summary of nano cosmeceuticals that are a risk to the environment**

<table>
<thead>
<tr>
<th>Nanoparticles</th>
<th>Risk</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>TiO2 (Titanium dioxide) Nanoparticles</td>
<td>If released in significant quantities, causing potential damage to marine life with chronic exposure. This ultimately affects aquatic ecological balances eradicating bacteria that are essential to ecosystem function and aid in the treatment of wastewater.</td>
<td>Hund-Rinke, K., &amp; Simon, M. Raj et al., 2012</td>
</tr>
<tr>
<td>Carbon-based nanomaterials</td>
<td>The word &quot;soot&quot; refers to all carbon black particles in the nanoparticle range that are discharged into the atmosphere as a result of incomplete combustion of fossil and renewable fuels. At higher concentrations, they disturb the metabolic activity of microbes by interrupting the biogeochemical cycle of nutrients and also upsetting the nutrient balance.</td>
<td>Taghavi et al., 2013 Khan, I., Saeed, K., &amp; Khan, I. (2019)</td>
</tr>
</tbody>
</table>
Table 5: Comparison of Consumer Safety (SCCS) and Scientific Committee on Cosmetics from the Nanomaterials Safety Assessment (ICCR) for regulatory guidelines in different countries.

<table>
<thead>
<tr>
<th>Nanoparticles</th>
<th>Toxic under biotic conditions as they induce oxidative stress; can cause mild harm in largemouth bass (fish).</th>
<th>Xia et al; Hood E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanoparticles of Ag, ZnO, fullerenes, silica, etc.</td>
<td>Taken up by plants and algae, thus producing toxicity and also hindering seed germination; impede the metabolic pathways affecting cell growth and function.</td>
<td>Guzmán et al., 2006</td>
</tr>
<tr>
<td>AgNP (Silver Nanoparticles)</td>
<td>For terrestrial plants, they display size and concentration-dependent toxicity. Exposure may reduce seed germination, impede the growth of seedlings, and alter the quantity and length of roots and shoots.</td>
<td>Budhani et al., 2019</td>
</tr>
<tr>
<td>Zinc Oxide Nanoparticles</td>
<td>The presence of ZnO nanoparticles in soil can affect soil elements, impacting microbial activity, and changes in soil physical properties.</td>
<td>Sheteiwy et al., 2021</td>
</tr>
</tbody>
</table>

Table 5: Summary of the Provision of Regulatory Guidelines

1. Guidelines for Industry Safety of Nanomaterials in Cosmetic Products from the Food and Drug Administration (FDA)

   The document "Guidance for Industry: Safety of Nanomaterials in Cosmetic Products" offers guidance on evaluating the safety of nanomaterials used in cosmetics. It covers topics like physicochemical characteristics, exposure routes, toxicity testing, and data requirements. The guidance highlights the importance of assessing the unique properties of nanomaterials and engaging with the FDA for safety discussions. While it does not impose legal obligations, it should be followed as recommendations unless specific regulatory requirements are mentioned. The guidance recommends evaluating data and testing methods for cosmetic products with new or modified properties containing nanomaterials, considering factors like physicochemical characteristics, exposure routes, and toxicological data. Manufacturers planning to use nanomaterials should consult with the FDA regarding necessary testing methods and data to demonstrate product safety, including short and long-term toxicity data.


   The Joint WG (Joint Industry/Regulator Working Group) members compiled a report to offer information and guidance to individuals involved in the utilization or assessment of nanomaterial safety in cosmetic products. The report highlights several key points regarding the safety assessment of nanomaterials in cosmetic products, such as the existing risk assessment framework and specific physicochemical parameters that should be measured during the raw material stage. Additionally, the report emphasizes the importance of conducting a comprehensive assessment of nanomaterials in cosmetic products, including systemic exposure, local effects, potential routes of exposure, and foreseeable uses of the product. Additionally, the report acknowledges the challenges in evaluating the safety of new nanomaterial cosmetic ingredients due to the EU Cosmetics Regulation's prohibition of animal testing.

3. Guidelines for the Safety Assessment of Nanomaterials in Cosmetics from the Scientific Committee on Consumer Safety (SCCS)

   The document provides current guidance regarding the evaluation of nanomaterial safety in cosmetic products. The main points of this document can be summarized as follows:

   - 3.1 Definition of Nanomaterial
     The dispersion of the particles, their solubility, and their permanence should all be taken into account when determining if a cosmetic element is a nanomaterial.

   - 3.2 Material Characterization
     According to the Cosmetics Regulation, the raw material, cosmetic formulation, and exposure must be described, and the materials must be recognized. It is recommended to quantify particle size using a variety of techniques, including electron microscopy.

   - 3.3 Safety Assessment
     To substantiate the safety of the cosmetic component, data from many alternative approaches must be gathered.

4. Comparison of Regulation of Cosmetics/Cosmeceuticals across Different Countries

   The subsequent section outlines several regulatory situations concerning cosmetic products in the United States of America (USA), the European Union (EU), India, ASEAN countries, and China. Additionally, Table 5 provides a comparative analysis of cosmetics/cosmeceuticals regulations across different regions, helping readers understand the diverse regulatory processes implemented in different countries.

Table 5: Summary on the comparative analysis for different regulatory guidelines for the following countries.
<table>
<thead>
<tr>
<th>Country</th>
<th>Regulatory Authority</th>
<th>Rules</th>
<th>Approval (Premarket)</th>
<th>Labeling</th>
<th>Labeling Declarations</th>
<th>Language of Label</th>
<th>Expiry Date</th>
<th>Safety</th>
<th>Warning</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>USFDA</td>
<td>Food, Drug and Cosmetics Act</td>
<td>No specific requirement</td>
<td>Must conform with the FP&amp;L and FD&amp;C and 740 of USFDA</td>
<td>21 CFR 701</td>
<td>English</td>
<td>Not required</td>
<td>Manufactur er responsibility</td>
<td>On the primary display panel</td>
</tr>
<tr>
<td>EU</td>
<td>EMEA</td>
<td>Council Directive 76/768/EE C</td>
<td>No specific requirement</td>
<td>Based on Council Directive</td>
<td>Cosmetic Directive, Article 6</td>
<td>National or member state</td>
<td>If the stability is &lt;30 months, → Date of minimum stability is &gt;30 months → days/months/years after opening is mentioned</td>
<td>Information file of the product is being maintained by the manufacturer</td>
<td>On both outer and inner label</td>
</tr>
<tr>
<td>India</td>
<td>CDSCO</td>
<td>Drugs and Cosmetics Act, 1940</td>
<td>Required under the state government licensing</td>
<td>Comply with D&amp;C rules 1945—Part XV</td>
<td>BIS and PCRO</td>
<td>English</td>
<td>It should have “Use before date”</td>
<td>The records of the product’s safety must be maintained by the manufacturer</td>
<td>On inner label</td>
</tr>
<tr>
<td>ASEAN</td>
<td>Food and Drug Adminstration (FDA)</td>
<td>ASEAN Cosmetic Directive</td>
<td>Required to comply with ASEAN Guidelines for Good Manufacturin g Practice.</td>
<td>Comply with ASEAN Cosmetic Directive.</td>
<td>Article 5 of the ASEAN Cosmetic Directive 05/01/ACCSQ PWG</td>
<td>English</td>
<td>Use within recommended best before or expiration date.</td>
<td>Keeping a Product Information File (PIF) on every product placed on the market.</td>
<td>Product Label</td>
</tr>
</tbody>
</table>
China (SAMR) | State Administrations for Market Regulation | Regulations concerning the Hygiene Supervision over Cosmetics from 1989. | Required to register NMPA or provincial MPAs | Review and Check by NMPA, CIQ (China Inspection and Quarantine Bureau) and national standard GB 5296.3-2008. | Cosmetic labeling requirements in China (GB 5296.3-2008) | Chinese | Not required | Regulatory compliance testing in product safety and efficacy according to Safety and Technical Standards for Cosmetics 2021 and Specifications for the Evaluation of Cosmetic Efficacy Claims | Hygiene Standard for Cosmetics 2007 lists the restrictions for ingredients

4.1 Differentiation of the different regulation guidelines in the USA, EU, India, ASEAN, and China

Regulations on cosmetics and cosmeceuticals differ across regions. In the United States, the Food and Drug Administration (FDA) governs the industry under the Food, Drug, and Cosmetics Act (FDCA), with limited pre-market approval requirements. The Voluntary Cosmetic Registration Program (VCRP) encourages information sharing, while the FDA has inspection authority for misbranded or tainted products. The European Union, through the European Medicines Evaluation Agency (EMEA), mandates product safety reports, designated marketing, and reporting of adverse effects. Nanomaterials are controlled under specific regulations, with the EU Cosmetics Product Notification Portal (CPNP) as the reporting portal. India regulates cosmetics under the Central Drug Standard Control Organization (CDSCO) and Bureau of Indian Standards (BIS), requiring comprehensive labeling and quality standards. Association of Southeast Asian Nations (ASEAN) aligns with the EU framework and emphasizes harmonization, while China is adopting regulations for nano ingredients disclosure. These diverse approaches aim to ensure consumer safety and product quality (Dhull et al., 2015; Cosmetic Labeling Guide, 2015; Dhapte et al., 2020; McDougall, 2011; Lim, 2021).

Conclusion

The application of nanotechnology in various fields such as cosmetics, cosmeceuticals, dermatology, biomedical studies, and others has received widespread appreciation due to its practical use. In recent years, the introduction of innovative medication delivery mechanisms and other advancements has further increased the popularity of cosmetics and cosmeceuticals and contributed to market growth. With the addition of nanotechnology, these products have become an essential component of daily life for many people and have gained greater acceptance among consumers worldwide. For instance, the cosmetic industry aims to deliver the appropriate amount of substances to targeted body parts and achieve long-term stability by using nanomaterials. Nanomaterials offer benefits such as increased surface area, high reactivity, unique properties, improved texture, and UV protection. Cosmetics containing nanomaterials are more effective than those containing microscale cosmetics.

Nanotechnology has been utilized in the medical and pharmaceutical fields and is also being applied in the cosmetics industry through the development of nano cosmeceuticals. The smaller size of nanomaterials provides advantages such as improved solubility, transparency, chemical reactivity, and stability. Various types of nanomaterials such as liposomes, ethosomes, solid lipid nanoparticles, nanocapsules, dendrimers, nanocrystals, cubosomes, and nanoemulsions are used in cosmetics. However, the use of nanotechnology has also raised concerns about its potential harmful effects due to its high penetrability. Nanoparticles can enter the body through various pathways and accumulate in organs, leading to toxicity and negative health effects. Additionally, factors such as quantity, route of exposure, and physicochemical properties influence their toxicity. They can enter the human body through inhalation, ingestion, or skin contact and can cause harm by damaging DNA, infiltrating cell layers, and causing neonatal toxicity. Proper evaluation of nanomaterials for immunological effects and safety is necessary before clinical use to ensure optimal and safe medical use.

Therefore, nanotechnology can be used to improve the quality of the environment by reducing waste production, greenhouse gas emissions, and hazardous chemical release. However, nanoparticles can also harm the environment by interfering with biochemical processes and changing environmental processes. Nanoparticles can contaminate soil and move into nearby waterways, and spills can cause large environmental releases. Nanoparticles are hazardous to aquatic creatures, and their mobility, bioavailability, and toxicity must be better understood to evaluate the hazards associated with their use in industrial products and environmental applications. It is crucial to consider the potential risks associated with nanotechnology and take appropriate measures to ensure the safety of consumers. Research and development in this field must prioritize safety and address potential health risks to avoid any
adverse effects. The benefits of nanotechnology are significant, but they must be balanced with careful consideration of its potential risks to ensure its responsible use in cosmetics, cosmeceuticals, and other fields.

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**Informed Consent Statement**

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**Conflicts of Interest**

There are no declarations of conflicts of interests from the authors.

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