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Assessment of Nanotechnological Advancements in Cosmetics: A Review

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ABSTRACT

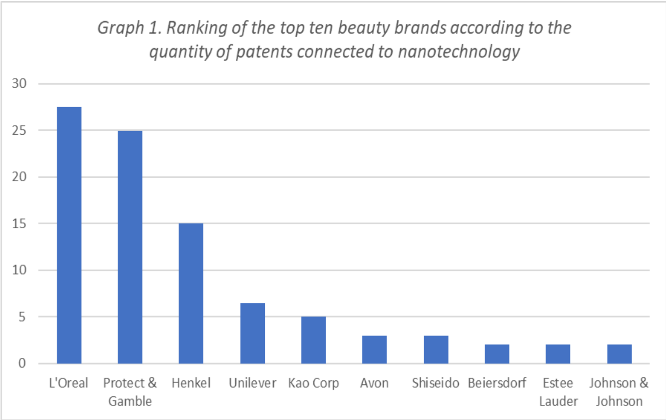
Nanotechnology is being used in the cosmetics industry to develop diagnostic and therapeutic products, offering improved product characteristics such as enhanced skin penetration, anti-aging impact, and UV protection. However, the use of nanomaterials in cosmetics raises concerns about their safety and 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.

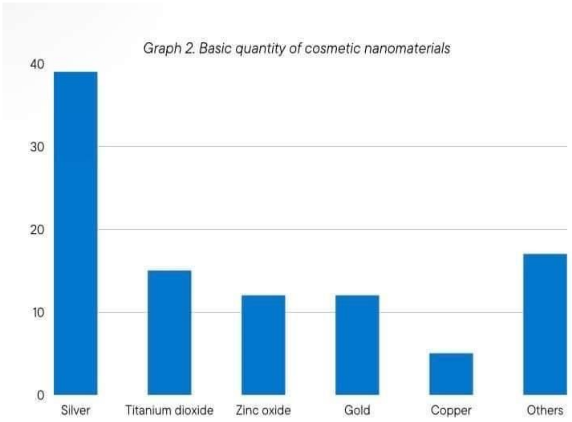
Introduction

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 Particl*es

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).

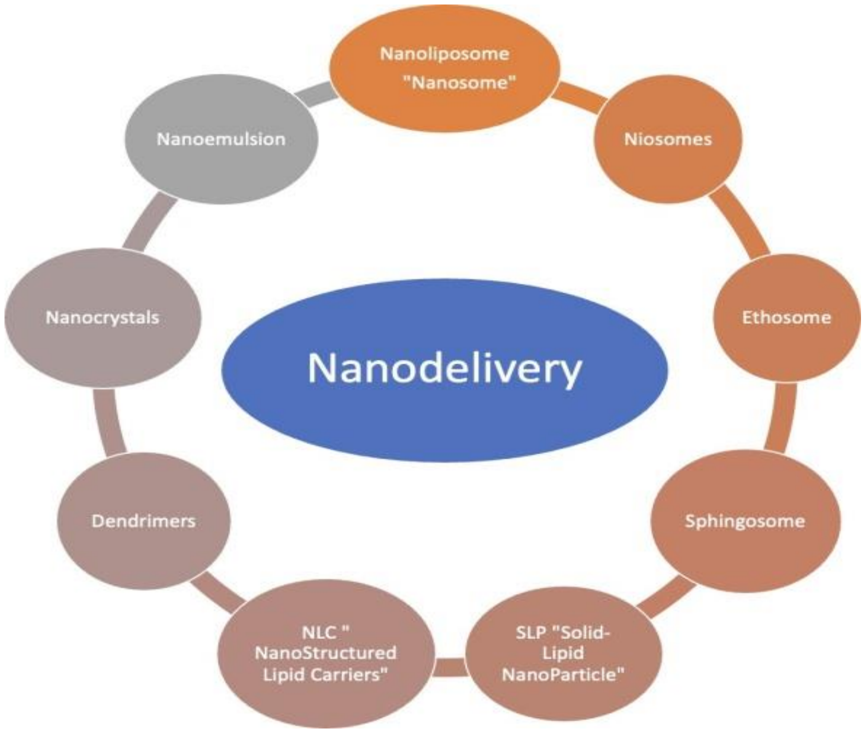


Fig. 1 Breadth Nano-formulation Types Breadth of Nano-formulation

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 nano-formulations 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 ans etc. (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*

Nanomaterials	**Advantages**	**Author**
UV Filters (Titanium Dioxide and Zinc Oxide)	Titanium dioxide, a white powder, is a non-toxic, safe, and well-tolerated UV filter in cosmetics.	Berger, M. (2012)
Antimicrobials (Gold and Silver nanomaterials)	Silver and silver-based combinations in cosmetics control bacterial growth and stabilize formulations for more than a year.	Gupta, V. et al,. (2022).
Silica nanoparticles	Silica Nanoparticles (SNPs) may alter treatment of various skin illnesses by controlling drug release.	Nafisi, S. et al,. (2017)
Nano-Hydroxyapatite	Nano-hydroxyapatite is a promising new material for restorative and preventative dentistry, with strong remineralizing effects and favorable results on tooth sensitivity.	Pepla, E. (2014)
Carbon black/Carbon-based nanoparticles	Carbon black is a highly effective black pigment that can be used in cosmetics to provide a rich, vivid black color and UV protection.	Yaroshchuk, A. E. et al,.(2015).
Nano-Organic (Tris-Biphenyl Triazine)	It is a nanoparticle (size 100 nm) used in sunscreens and skin care products for its powerful benefits in sun protection.	Couteau, C. et al,.(2015)
Bucky Balls (Buckminsterfullerene/ C60)	Buckminsterfullerene is a powerful antioxidant that can protect skin from oxidative stress caused by free radicals and UV exposure.	Lens, M. (2009)
Miscellaneous	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..	Singh, T.G. et al,.(2016) Morganti, P. et al,. (2008)

Table 2: *List of advantages of various nanoformulations*

Nano formulation	**Advantages**	**Authors**
Nanoliposomes	Biodegradable, biocompatible, amphiphilic, and high skin penetration.	Rigano, L. and Lionetti, N. (2021) Santos, A.C et al. (2019)
	Nanoliposomes can effectively transport flavors, nutrients, and antimicrobial agents to enhance sensory attributes and extend the shelf life of food items.	Mozafari et al., 2008.
	Nanoliposomes are attractive "smart" drug delivery systems due to their scalable production using natural, affordable ingredients, as well as their biocompatibility and biodegradability.	Demirci et al., (2017)
Niosomes	High efficiency, penetration, bioavailability, and stability of drugs.	Kusuma Priya, M.D et al. (2020)
	Niosomes, composed of stable non-ionic surfactants, are an attractive and cost-effective option for drug delivery due to their ease of formulation, scalability, superior stability, and improved physical and chemical properties compared to liposomes.	Khatoon M. et al. (2017) Abdelkader H., Alani A.W., Alany R.G. (2014) Yu-Cheng T., Subho M., Leaf H. (2009)
	Niosomes offer versatile drug transport capabilities with various configurations like proniosomes, discomes, and aspasomes.	Sepideh, K., Morteza, Y., (2017)
	Due to their amphiphilic structure, it offers a broad range of solubility for drug molecules.	Madhav NV, Saini A (2011).

	It enhances drug penetration through the skin and improves oral bioavailability of poorly soluble drugs.	Kalra N, Jeyabalan G, Singh G, Choudhary S (2016).
Ethosomes	High efficiency and penetration of cosmetic delivery into the skin	Sudhakar, C.K., Upadhyay, N., Jain, S. and Charyulu, R.N. (2012)
	It effectively penetrates the skin more than liposomes, and improves skin penetration and its ability to target deeper skin layers in various skin conditions.	Nandure, H., Puranik, P., Giram, P., Lone, V. (2013)
	It has many routes of administration listed as the medication will remain encapsulated in its vesicular structures for a longer time in the systemic circulation and have a lower harmful effect, if a selective absorption is possible.	Mishra, D., Dhote, V. K., Mishra, P. K., Balekar, N. (2017)
Sphingosomes	Restore the skin's barrier function and repair dry and damaged skin	Kusuma Priya, M.D. et al. (2020)
	The most efficient new vesicular drug delivery technology due to enhanced drug loading capacity, high stability, targets specific organs and tissues, and their optimal nature and safety to the host cells.	Chaudhari, S., Gaikwad, S. (2020)
	Its membrane lipids are highly compatible with skin since they belong to the same chemical compound family as epidermal lipids, which have penetration enabling properties.	Pawar, G. (2022)
Solid lipid nanoparticles (SLNs)	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.	Fytianos, G., Rahdar, A.and Kyzas, G.Z. (2020)
	Using biodegradable physiological lipids reduces the risk of acute and long-term toxicity and avoiding organic solvents in production processes.	Rupenagunta, A., et. al. (2011)
	Solid lipid nanoparticle-based sunscreens may function as permeation enhancers, which increases the active moiety's tolerance and penetration.	Jose, J., & Netto, G. (2019)
	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.	Wissing, S.A., and Müller, R.H.
	It enhances the bioavailability of molecules with poor water solubility.	Fahr, A. and Liu, X. (2007)
	It function as occlusives, which indicates that they can be utilized to increase the skin's water content.	Wissing, S.A., Lippacher, A., Müller, R.H., 2001
	Long duration of action, ease of large-scale production, high bioavailability and biodegradability.	Fytianos, G., Rahdar, A.and Kyzas, G.Z. (2020)
Nanostructured lipid carriers (NLCs)	It has occlusive properties, hence, reduces transepidermal water loss (TEWL) leading to an increase in skin hydration.	Dubey, A., Prabhu, P., & Kamath, J. V. (2012)
	Compared to conventional products, it has a higher increase in hydration and elasticity of the skin.	Müller, R.H. et al. (2007)
	Encapsulating inorganic sunscreens in NLC, is a potential method to produce well-tolerated sunscreens with high SPF.	Dubey, A., Prabhu, P., & Kamath, J. V. (2012)
	Due to the scattering of UV radiation caused by their particulate character, they are protective like titanium dioxide.	Samimi S., Maghsoudnia N., Eftekhari R.B., Dorkoosh F. (2021)
	It has a long shelf life which may provide ease to large-scale production.	Fytianos, G., Rahdar, A. & Kyzas, G.Z. (2020)

	When compared to other delivery methods, it is more affordable.	Pardeike, J., Hommoss, A., & Müller, R. H. (2009)
Dendrimers	High solubility, controlled-release formulation, and stable drug stability in cosmetic formulations.	Fytianos, G., Rahdar, A.and Kyzas, G.Z. (2020)
	Dendrimer-molecule conjugate system creates effective anti-acne agent and transparent sunscreen formulation.	Tolia, G., & Choi, H. (2020, November 15)
	Carbosiloxane dendrimer provides water and sebum resistance.	Lohani, A., Verma, A., Joshi, H., Yadav, N., & Karki, N. (2014)
Nanoemulsions	Transparent, stable, and amphiphilic	Fytianos, G., Rahdar, A.and Kyzas, G.Z. (2020)
	Occlusive properties increase skin moisture and reduce redness.	Hameed, A., et al. (2018)
Nanocrystal	High drug solubility, particle distribution, adhesiveness, dissolution rate, skin penetration of poorly water-soluble drugs	Nguyen, T.A.and Rajendran, S. (2020)

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

Nanoparticles	**Risk to Health**	**Author**
TiO2 (Titanium dioxide)	Photoreactive nano-TiO2 generates reactive oxygen species, damaging cells and potentially causing organ penetration and consumer risk, while also leading to DNA damage, inflammation, and disease.	Dréno et al. (2019) Grande, F., & Tucci, P. (2016). Trouiller et al. (2009).
ZnO (Zinc oxide)	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.	Keerthana, S., & Kumar, A. (2020) Frober et al. (2020);
		Hussein et al.(2020) Wang et al. (2019) and Chen et al. (2019)
AgNP (Silver nanoparticle)	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.	Ferdous & Abderrahim Nemmar (2020) Lin, C. (2017) Al-Doaiss, A. et al. (2020)
Carbon Black nanoparticles	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.	Tang et al. (2020) Li, N., et al. (2002) Li, R. et al. (2014)

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

Nanoparticles	**Risk**	**Author**
TiO2 (Titanium dioxide) Nanoparticles	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.	Hund-Rinke, K., & Simon, M. Raj et al., 2012
Carbon-based nanomaterials	The word "soot" 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.	Taghavi et al., 2013 Khan, I., Saeed, K., & Khan, I. (2019)

Titanium, polystyrene, and fullerene nanoparticles	Toxic under biotic conditions as they induce oxidative stress; can cause mild harm in largemouth bass (fish).	Xia et al; Hood E.
Nanoparticles of Ag, ZnO, fullerenes, silica, etc.	Taken up by plants and algae, thus producing toxicity and also hindering seed germination; impede the metabolic pathways affecting cell growth and function.	Guzmán et al., 2006
AgNP (Silver Nanoparticles)	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.	Budhani et al., 2019
Zinc Oxide Nanoparticles	The presence of ZnO nanoparticles in soil can affect soil elements, impacting plant composition and growth leading to decreased plant growth, reduced soil fertility, and lower crop yields due to altered nutrient cycling, reduced microbial activity, and changes in soil physical properties.	Sheteiwy et al., 2021 Rajput et al., 2021

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.
2. Report of the ICCR Working Group—Safety Approaches to Nanomaterials in Cosmetics, published by the International Cooperation on Cosmetics Regulation (ICCR)	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/ Cosmeceutical s 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.*

Country	**Regulatory Authority**	**Rules**	**Approval (Premarket)**	**Labeling**	**Labeling Declarations**	**Language of Label**	**Expiry Date**	**Safety**	**Warning**
USA	USFDA	Food, Drug and	No specific	Must conform	21 CFRR 701	English	Not required	Manufactur er	On the
		Cosmetics Act	requirement	with the FP&L and FD&C	and 740 of USFDA			responsibilit y	primary display panel
EU	EMEA	Council Directive 76/768/EE C	No specific requirement	Based o n Council Directive	Cosmetic Directive, Article 6	National or member state	If the stability is <30 months → Date of minimu m stability is >30 months → days/mo nths/yea rs after opening is mention ed	Information file of the product isbeing maintained by the manufacture r	On both outer and inner label
India	CDSCO	Drugs and Cosmetics Act, 1940	Required under thestate government licensing	Comply with D&C rules 1945— Part XV	BIS and PCRO	English	It should have "Use before date"	The records of the product's safety must be maintained by the manufacture r	On inner label
ASEAN	Food and Drug Adminis tration (FDA)	ASEAN Cosmetic Directive	Required to comply with ASEAN Guidelines for Good Manufacturin g Practice.	Comply with ASEAN Cosmetic Directive.	Article 5 of the ASEAN Cosmetic Directive 05/01/ACCSQ PWG	English	Use within recomm ended best before or expiratio n date.	Keeping a Product Information File (PIF) on every product placed on the market.	Product Label

China	State Administration for Market Regulation (SAMR)	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 2021and Specification 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 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-Pawar 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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Conflicts of Interest

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

References

Ahmad, J. (2021, September 15). Lipid Nanoparticles Based Cosmetics with Potential Application in Alleviating Skin Disorders. Retrieved from https://doi.org/10.3390/cosmetics8030084

Ahmad, U., Ahmad, Z., Khan, A. A., Akhtar, J., Singh, S. P., & Ahmad, F. J. (2018). Strategies in development and delivery of nanotechnology based cosmetic products. Drug research, 68(10), 545-552.

Altmeyer, D. M. P. (2020, October 29). Tris-biphenyl triazines (nano). Altmeyers.org; Altmeyers Encyclopedia. https://www.altmeyers.org/ en/cosmetology/tris-biphenyl-triazines-nano-150808

ASEAN Cosmetic Handbook. (n.d.). Retrieved May 6, 2023, from https://www.aseancosmetics.org/docdocs/technical.pdf

Berger, M. (2012, March 9). Nanotechnology in cosmetics. Nanotechnology. Retrieved May 5, 2023, from https://www.nanowerk.com/ nanotechnology-in-cosmetics.php

Bierkandt, F. S., Leibrock, L., Wagener, S., Laux, P., & Luch, A. (2018). The impact of nanomaterial characteristics on inhalation toxicity. Toxicology Research, 7(3), 321–346. https://doi.org/10.1039/c7tx00242d

Bilal, M., Iqbal, H.M.N. (2020, March 13). New Insights on Unique Features and Role of Nanostructured Materials in Cosmetics. Retrieved from https://doi.org/10.3390/cosmetics7020024

Budhani, S., Egboluche, N. P., Arslan, Z., Yu, H., & Deng, H. (2019). Phytotoxic effect of silver nanoparticles on seed germination and growth of terrestrial plants. Journal of Environmental Science and Health, Part A, 37(4), 330–355. https://doi.org/10.1080/10590501.2019.1676600

Chaudhari, S. P., & Gaikwad, S. U. (2020). Sphingosomes: A novel lipoidal vesicular drug delivery system. Journal of Science and Technology, Volume 5, 261–267. https://doi.org/10.46243/jst.2020.v5.i4.pp261-267

Couteau, C., Paparis, E., Chauvet, C., & Coiffard, L. (2015). Tris-biphenyl triazine, a new ultraviolet filter studied in terms of photoprotective efficacy. International Journal of Pharmaceutics, 487(1-2), 120-123.

Dhapte-Pawar, V., Kadam, S., Saptarsi, S., & Kenjale, P. P. (2020). Nanocosmeceuticals: Facets and aspects. Future Science OA, 6(10), FSO613.

Dhull, K., SWAGAT, T., & HARISH, D. (2015). Cosmetics: regulatory scenario in USA, EU and India. http://dspace.chitkara.edu.in/ xmlui/handle/1/665

Dréno, B., Alexis, A., B. Chuberre, & Marinovich, M. (2019). Safety of titanium dioxide nanoparticles in cosmetics. Journal of the European Academy of Dermatology and Venereology, 33(S7), 34–46. https://doi.org/10.1111/jdv.15943

Dubey, A., Prabhu, P., & Kamath, J. V. (2012). Nano Structured lipid carriers: A Novel Topical drug delivery system. International journal of PharmTech research, 4(2), 705-714.

Fahr, A. and Liu, X. (2007). Drug delivery strategies for poorly water soluble drugs, Expert Opinion on Drug Delivery. 4(4): 403-416.

Ferdous, Z., & Nemmar, A. (2020). Health Impact of Silver Nanoparticles: A Review of the Biodistribution and Toxicity Following Various Routes of Exposure. International journal of molecular sciences, 21(7), 2375. https://doi.org/10.3390/ijms21072375

Food and Drug Administration. (2014). Guidance for Industry: Safety of Nanomaterials in Cosmetic Products. Silver Spring, MD, USA: Food and Drug Administration. Retrieved from https://www.fda.gov/regulatory-information/search-fda-guidance-documents/guidance-industry-saf ety-nanomaterials-cosmetic-products (Accessed May 6, 2023).

Fytianos, G., Rahdar, A., & Kyzas, G. Z. (2020). Nanomaterials in Cosmetics: Recent Updates.

Nanomaterials (Basel, Switzerland), 10(5), 979. https://doi.org/10.3390/nano10050979

G, D.B., P, V.L. Recent advances of non-ionic surfactant-based nano-vesicles (niosomes and proniosomes): a brief review of these in enhancing transdermal delivery of drug. Futur J Pharm Sci 6, 100 (2020). https://doi.org/10.1186/s43094-020-00117-y

Ge, X., Wei, M., He, S., & Yuan, W. E. (2019). Advances of Non-Ionic Surfactant Vesicles (Niosomes) and Their Application in Drug Delivery. Pharmaceutics, 11(2), 55.

https://doi.org/10.3390/pharmaceutics11020055Wissing, S.A., Müller, R.H., 2001b. Solid lipid nanoparticles (SLNTM)—a novel carrier for UV blockers. Pharmazie 56, 783–786.

Grande, F., & Tucci, P. (2016). Titanium dioxide nanoparticles: A risk for human health? Mini Reviews in Medicinal Chemistry, 16(9), 762–769. doi:10.2174/1389557516666160321114341

Gupta, V., Mohapatra, S., Mishra, H., Farooq, U., Kumar, K., Ansari, M. J., … Iqbal, Z. (2022). Nanotechnology in cosmetics and cosmeceuticals-A review of latest advancements. Gels (Basel, Switzerland), 8(3), 173. doi:10.3390/gels8030173

Guzmán, K. A. D., Taylor, M. R., & Banfield, J. F. (2006). Environmental risks of nanotechnology: National Nanotechnology Initiative funding, 2000-2004. Environmental Science & Technology, 40(5), 1401–1407. https://doi.org/10.1021/es0515708

Hameed, A., Rida Fatima, G., Malik, K., Muqadas, A., & Rehman, M. (2018). Scope of Nanotechnology in Cosmetics: Dermatology and Skin Care Products. Journal of Medicinal and Chemical Sciences, 2019(2), 9–16. https://tinyurl.com/mr2jr3jw

Hood E. (2004). Fullerenes and Fish Brains: Nanomaterials Cause Oxidative Stress. Environmental Health Perspectives, 112(10), A568.

Hund-Rinke, K., & Simon, M. (2006). Ecotoxic effect of photocatalytic active nanoparticles (TiO2) on algae and daphnids (8 pp). Environmental Science and Pollution Research International, 13(4), 225–232. https://doi.org/10.1065/espr2006.06.311

International Cooperation on Cosmetics Regulation (ICCR). (n.d.). ICCR. Retrieved from https://www.iccr-cosmetics.org/

Jose, J., & Netto, G. (2019). Role of solid lipid nanoparticles as photoprotective agents in cosmetics.

Journal of Cosmetic Dermatology, 18(1), 315-321.

Katz, L.M., Dewan, K., Bronaugh, R.L. (2015, July 6). Nanotechnology in cosmetics. Retrieved from https://doi.org/10.1016/j.fct.2015.06.020

Keerthana, S., & Kumar, A. (2020). Potential risks and benefits of zinc oxide nanoparticles: a systematic review. Critical reviews in toxicology, 50(1), 47–71. https://doi.org/10.1080/10408444.2020.1726282

Khan, I., Saeed, K., & Khan, I. (2019). Nanoparticles: Properties, applications and toxicities. Arabian Journal of Chemistry, 12(7), 908–931. https://doi.org/10.1016/j.arabjc.2017.05.011

Khoee, S., & Yaghoobian, M. (2017). Niosomes: A novel approach in modern drug delivery systems. Nanostructures for Drug Delivery, 207-237. https://doi.org/10.1016/b978-0-323-46143-6.00006-3

Kumar Mishra, D., Balekar, N., Dhote, V., & Kumar Mishra, P. (2017). Ethosomes: A novel carrier for dermal or transdermal drug delivery. In Carrier-Mediated Dermal Delivery (pp. 357–383). Jenny Stanford Publishing.

Kusuma Priya, M.D.; Kumar, V.; Damini, V.K.; Eswar, K.; Reddy, K.R.; Brito Raj, S.; Sucharitha, P. Somes: A review on composition, formulation methods and evaluations of different types of "somes" drug delivery system. Int. J. Appl. Pharm. 2020, 12, 7–18.

Lens, M. (2009). Use of fullerenes in cosmetics. Recent Patents on Biotechnology, 3(2), 118-123.

Li, N., Wang, M., Oberley, T.D., Sempf, J.M., Nel, A.E. (2002). Comparison of the pro-oxidative and proinflammatory effects of organic diesel exhaust particle chemicals in bronchial epithelial cells and macrophages. Journal of Immunology, 169(8), 4531-4541.

Li, R., Ji, Z., Chang, C. H., Dunphy, D. R., Cai, X., Meng, H., ... & Nel, A. E. (2014). Surface interactions with compartmentalized cellular phosphates explain rare earth oxide nanoparticle hazards and provide opportunities for safer design. ACS nano, 8(2), 1771-1783. https://doi.org/10.1021/nn405738h

Li, Y., Zhang, P., Ben Zhong Tang, & Boraschi, D. (2022). Editorial: Immunological Effects of Nano-Imaging Materials. Frontiers in Immunology, 13. https://doi.org/10.3389/fimmu.2022.886415

Lim, G. Y. (2021, January 12). cosmeticsdesign-asia. Enterprise boost: China ready to allow use of nano and biotech materials in cosmetics for the first time: https://www.cosmeticsdesign-asia.com/Article/2021/01/12/Enterprise-boost-China-ready-to-allow-use-of-nano-and-biotech-materials-in-cosmetics-for-the-first-time?utm_source=copyright&utm_m edium=OnSite&utm_campaign

Liu, W.Y., Lin, C., Lee, Y.S., Deng, D.J. (2012, September 4). On gender differences in consumer behavior for online financial transaction of cosmetics. Retrieved from https://doi.org/10.1016/j.mcm.2012.08.010

Lohani, A., Verma, A., Joshi, H., Yadav, N., & Karki, N. (2014). Nanotechnology-Based Cosmeceuticals.

ISRN Dermatology (Print), 2014, 1–14. https://doi.org/10.1155/2014/843687

McDougall, A. (2011). Cosmetics Serve as Model for Other industry in ASEAN Market. Retrieved from http://www.cosmeticsdesign.com

Medina-Ramirez, I. E., Jimenez-Chavez, A., & De Vizcaya-Ruiz, A. (2023). Toxicity of nanoparticles. In Antimicrobial Activity of Nanoparticles (pp. 249–284). Elsevier.

Morganti, P.; Morganti, G. Chitin nanofibrils for advanced cosmeceuticals. Clin. Dermatol. 2008, 26, 334–340.

Muller, R. H., Hommoss, A., Pardeike, J., & Schmidt, C. (2007). Lipid nanoparticles (NLC) as novel carrier for cosmetics: Special features & state of commercialisation. SÖFW-journal, 133(9).

Nafisi, S., Schäfer-Korting, M., & Maibach, H. I. (2017). Measuring Silica Nanoparticles in the Skin. In Springer eBooks (pp. 1141–1164). https://link.springer.com/referenceworkentry/10.1007/978-3-319-32383-1_44

Nandure, H. P., Puranik, P., Giram, P., & Lone, V. (n.d.). Ethosome: A Novel Drug Carrier. Ijpras.com. Retrieved May 6, 2023, from https://ijpras.com/storage/models/article/DARuKhG1eizCumQU4mdOf4vUh3RE52BPRDFI8Gn7cRrtxF2pUrhNk9jBKyP0/ethosome-a-novel-drug-carrier.pdf

Nanomaterials in Cosmetics. Retrieved May 6, 2023, from

https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021DC0403&from=EN

Nguyen, T.A.; Rajendran, S. Current Commercial Nanocosmetic Products; Elsevier: Amsterdam, The Netherlands, 2020; ISBN 9780128222867.

Nowack, B., & Bucheli, T. D. (2007). Occurrence, behavior and effects of nanoparticles in the environment. Environmental Pollution (Barking, Essex: 1987), 150(1), 5–22. https://doi.org/10.1016/j.envpol.2007.06.006

Pawar, G. (2022). Sphingosomes: Highlights of the progressive journey and their application perspectives in modern drug delivery. International Journal of Medical & Pharmaceutical Sciences, 12(01). https://doi.org/10.31782/ijmps.2022.12101

Pepla, E. (2014, September 1). Nano-hydroxyapatite and its applications in preventive, restorative and regenerative dentistry: a review of literature. PubMed Central (PMC). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4252862/

Raj, S., Jose, S., Sumod, U.S., Sabitha, M. (2012). Nanotechnology in cosmetics: Opportunities and challenges. Retrieved from https://doi.org/10.4103%2F0975-7406.99016

Rajput, V. D., Minkina, T. M., Behal, A., Sushkova, S. N., Mandzhieva, S., Singh, R., Gorovtsov, A., Tsitsuashvili, V. S., Purvis, W. O., Ghazaryan, K. A., & Movsesyan, H. S. (2021). Effects of zinc-oxide nanoparticles on soil, plants, animals and soil organisms: A review. Environmental Pollution, 288, 117795. https://doi.org/10.1016/j.envpol.2021.117795.

Ray, P. C., Yu, H., & Fu, P. P. (2009). Toxicity and environmental risks of nanomaterials: challenges and future needs. Journal of environmental science and health. Part C, Environmental carcinogenesis & ecotoxicology reviews, 27(1), 1–35. https://doi.org/10.1080/10590500802708267

Rupenagunta, A., Somasundaram, I., Ravichandiram, V., Kausalya, J., Senthilnathan, B. (2011). Solid lipid nanoparticles- A versatile carrier system. J Pharm Res. 4(7): 2069- 2075.

Samimi, S. et al. (2019) Lipid-based nanoparticles for Drug Delivery Systems, Lipid-Based Nanoparticles for Drug Delivery Systems. Elsevier. Available at: https://www.researchgate.net/publication/333402294_Lipid-Based_Nanoparticles_for_Drug_Deliv ery_Systems (Accessed: May 6, 2023).

Santos, A.C.; Morais, F.; Simões, A.; Pereira, I.; Sequeira, J.A.D.; Pereira-Silva, M.; Veiga, F.; Ribeiro, A. Nanotechnology for the development of new cosmetic formulations. Expert Opin. Drug Deliv. 2019, 16, 313–330.

Sharma, A. K., & Pundarikakshudu, K. (2019). Regulatory aspects of traditional Indian medicines (TIM) in India and in international purview. Journal of AOAC International, 102(4), 993-1002.

Sheteiwy, M.S., Shaghaleh, H., Hamoud, Y.A., et al. (2021). Zinc oxide nanoparticles: potential effects on soil properties, crop production, food processing, and food quality. Environmental Science and Pollution Research, 28, 36942–36966. https://doi.org/10.1007/s11356-021-14542-w.

Singh, T.G.; Sharma, N. Nanobiomaterials in cosmetics: Current status and future prospects. In Nanobiomaterials in Galenic Formulations and Cosmetics; William Andrew: Norwich, NY, USA, 2016; pp. 149–174.

Smita, S., Gupta, S. K., Bartonova, A., Dusinska, M., Gutleb, A. C., & Rahman, Q. (2012). Nanoparticles in the environment: assessment using the causal diagram approach. Environmental Health: A Global Access Science Source, 11(S1). https://doi.org/10.1186/1476-069x-11-s1-s13

Sudhakar, C.K.; Upadhyay, N.; Jain, S.; Charyulu, R.N. Ethosomes as non-invasive loom for transdermal drug delivery system. In Nanomedicine and Drug Delivery; Apple Academic Press: Point Pleasant, NJ, USA, 2012; ISBN 9781466560079.

Taghavi, S. M., Momenpour, M., Azarian, M., Ahmadian, M., Souri, F., Taghavi, S. A., Sadeghain, M., & Karchani, M. (2013). Effects of Nanoparticles on the Environment and Outdoor Workplaces. Electronic physician, 5(4), 706–712. https://doi.org/10.14661/2013.706-712

Tang, J., Cheng, W.-T., Gao, J., Li, Y., Yao, R., Rothman, N., Lan, Q., Campen, M. J., Zheng, Y., & Leng,

S. (2020). Occupational exposure to carbon black nanoparticles increases inflammatory vascular disease risk: an implication of an ex vivo biosensor assay. Particle and Fibre Toxicology, 17(1). https://doi.org/10.1186/s12989-020-00378-8

Teng, C., Jiang, C., Gao, S., Liu, X., & Zhai, S. (2021). Fetotoxicity of Nanoparticles: Causes and Mechanisms. Nanomaterials, 11(3), 791–791. https://doi.org/10.3390/nano11030791

Tolia, G., & Choi, H. (2020, November 15). The Role of Dendrimers in Topical Drug Delivery. PharmTech. https://www.pharmtech.com/view/role-dendrimers-topical-drug-delivery

Trouiller, B., Reliene, R., Westbrook, A., Solaimani, P., & Schiestl, R. H. (2009). Titanium dioxide nanoparticles induce DNA damage and genetic instability in vivo in mice. Cancer Research, 69(22), 8784–8789. doi:10.1158/0008-5472.CAN-09-2496

U.S. Food & Drug Administration. (2015). Cosmetic labeling guide. https://www.fda.gov/regulatory-information/search-fda-guidance-documents/cosmetic-labeling-gui de#labeling_requirements

Wissing, S. A., & Müller, R. H. (2001). A novel sunscreen system based on tocopherol acetate incorporated into solid lipid nanoparticles. International journal of cosmetic science, 23(4), 233-243.

Wissing, S.A., Lippacher, A., Müller, R.H., 2001. Investigations on the occlusive properties of solid lipid nanoparticles (SLNTM). J. Cosm. Sci. 52, 313–323.

Xia, T., Kovochich, M., Brant, J., Hotze, M., Sempf, J., Oberley, T., Sioutas, C., Yeh, J. I., Wiesner, M. R., & Nel, A. E. (2006). Comparison of the abilities of ambient and manufactured nanoparticles to induce cellular toxicity according to an oxidative stress paradigm. Nano letters, 6(8), 1794–1807. https://doi.org/10.1021/nl061025k

Xu, L., Liang, H. W., Yang, Y., & Yu, S. H. (2018). Stability and Reactivity: Positive and Negative Aspects for Nanoparticle Processing. Chemical reviews, 118(7), 3209–3250. https://doi.org/10.1021/acs.chemrev.7b00208.

Yaroshchuk, A. E., Yaroshchuk, E. G., & Vorobyova, V. V. (2015). The role of carbon black nanoparticles in cosmetic industry. Nanotechnologies in Russia, 10(9-10), 649-656.

Zarrabi, A., Alipoor Amro Abadi, M., Khorasani, S., Mohammadabadi, M. R., Jamshidi, A., Torkaman, S., Taghavi, E., Mozafari, M. R., & Rasti, B. (2020). Nanoliposomes and Tocosomes as Multifunctional Nanocarriers for the Encapsulation of Nutraceutical and Dietary Molecules. Molecules (Basel, Switzerland), 25(3), 638. https://doi.org/10.3390/molecules25030638

Zhang, J., Wang, F., Yalamarty, S. S. K., Filipczak, N., Jin, Y., & Li, X. (2022). Nano Silver-Induced Toxicity and Associated Mechanisms. International Journal of Nanomedicine, 17, 1851–1864. https://doi.org/10.2147/ijn.s355131

Zinc oxide nanoparticles: a systematic review, Critical Reviews in Toxicology, DOI:10.1080/10408444.2020.1726282