

Nanoparticles in Cosmetics: Unexpected Threats and Protection

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Abstract : In regard to a research and development, nanotechnology is making some notable strides, introducing novel methods that heavily increase the efficacy of things. To get around some of the challenges of traditional strategies, the cosmeceutical industry, which sits at the nexus of cosmetics and medicines, is increasingly turning to nanotechnology. Cosmetics have seen a major growth as a personal care product sector in recent years, as well as an immense rise in usage. Nano cosmeceuticals, a subset of this field, offering remedies for a variety of skin, hair, lip, and nail care difficulties, including phototoxicity, becoming older, hyperpigmentation, dandruff, and hair loss. However, the use of nanoparticles in cosmeceuticals have given rise to reasonable concerns about nanotoxicology, in particular in regard to the effects that nanoparticles joining the skin could have on one's health. This worry was brought on by nanoparticles' particular capacity to cross the epidermal barrier, raising doubts about how they might have adverse impacts on human health. In this context, some of the main challenges facing cosmetics manufacturers include ensuring the safety and biocompatibility of nanoparticles, comprehending their long-lasting effects on people, and managing potential environmental implications. An effective strategy for overcoming such challenges and securing the sustainable and ethical use of nanoparticles in skincare requires both rigorous rules and ongoing study. The most fascinating aspects of the field of nanotechnology in cosmeceuticals are the broad array of carriers used for the administration of these specialized products, the evaluation of the benefits and drawbacks of commercial formulations, a thorough investigation of toxicity issues, and an understanding of limitations imposed by nano cosmeceuticals.

Keywords : NANOTECHNOLOGY , FORMULATION , TOXICITY , REGULATIONS, SAFETY, COSMETICS, NANOPARTICLES.

INTRODUCTION

The revolutionary impact produced by nanotechnology, considered by many as one of the most important discoveries of the twenty-first century, is expected to have a dramatic shift on the cosmetics industry. The word "nanotechnology" was created through the juxtaposition of the word's "technology" with the Greek letter "nano," which means "dwarf." This designation works since nanotechnology embraces all scientific and technical techniques used to alter or perform with particles having a size between one and one hundred nanometers. The creation of novel formulations and delivery methods that may dramatically enhance the efficacy and performance of these goods is made possible by the previously unheard-of capacity to function at the

nanoscale, which has shifted the market for cosmetics and personal care products. Nanotechnology provides the ability to open up fresh opportunities in skincare, cosmetics, and personal grooming, ushering in a new era of cosmetics that can address a broad range of customer requirements with unmatched accuracy and efficacy. (Tile et al., 2016) . Indeed, after 1959, the adoption and utilization of nanotechnology in various fields, including cosmetics, healthcare, and dermatological formulations, have become increasingly prevalent. This era marked a significant turning point in the application of nanotechnology, as scientists and researchers began to harness the unique properties and capabilities of nanoparticles to develop advanced products and solutions. In the realm of cosmetics, nanotechnology has enabled the creation of nano cosmeceuticals and nanoscale ingredients that can penetrate the skin more effectively. This has paved the way for the development of skincare and makeup products with enhanced properties, such as improved moisturization, sun protection, and anti-aging effects. Nanoparticles have also been employed to encapsulate and deliver active ingredients, allowing for targeted and controlled release, which is particularly beneficial in dermatological formulations. (Clunan et al., 2014). Actually, the study of nanotechnology is an intersection of disciplines involving many scientific fields, such as chemistry, physics, engineering, biology, and more. Its origins may be found in early civilizations including the Romans, Greeks, and Egyptians, who demonstrated a primitive form of nanoparticle-based technology although had current information and naming. These prehistoric people knew the avenues of manipulating materials at the nanoscale as early as 4000 BC. Papers from the past suggest they used nanoscale particles for a variety of goals, including their development of hair colors based on nanomaterials. Although the fact that they lacked the advanced equipment and information we have today, their discoveries showed a primitive understanding of the special qualities and power of nanoparticles to change the qualities of materials, such as color. Whilst not considered as "nanotechnology" at the time, these ancient practices paved the way for the development and spread of nanoscience and nanotechnology in being successful years past. Today, we have a much deeper comprehension of nanoscale phenomena and can apply such ideas to a variety of professions, such as materials science, electronics, cosmetics, and healthcare. Persistent research and development in the field of nanotechnology is easing the way for ground-breaking achievements in a variety of industry. (Zhan et al., (2018). The cosmetics industry has indeed wholeheartedly embraced nanotechnology, with manufacturers and researchers leveraging its capabilities to meet the ever-increasing consumer demand for elegance and beauty. This integration of nanotechnology has been a gradual but significant evolution in the industry, leading to the development and use of various nanoscale structures and particles to enhance cosmetic products.

1.**Cubosomes** : this are lipid-based nanotechnology that can be utilized to convey and encapsulate chemicals in cosmetic compositions. Cubosomes promote the effect of apparel by allowing substance to pass through the skin quicker (Prasad et al., 2006).

2. **Nano emulsions**: At the nanoscale, nano emulsions are limited droplets of oil or other elements distributed in water. They are utilized in the cosmetics industry in order to create stable formulations that boost the performance and texture of items like lotions and creams (Chalmers, et al., 2012)

3.**Curling Tongs and Razors**: Razors and curling tongs: For enhancing these items' what nanotechnology may be used. For instance, razors with nano-coated materials will be more durable and sharper, enabling a better shaving experience (Nainu et al., 2021)

4.**Dendrimers** : Highly branched, nanoscale molecules nicknamed dendrimers are able to carry and release chemical substances under regulated conditions. They are used in cosmetics, particular for skin care and anti-aging remedies.

5. Antiaging products : Various anti-aging cosmetic substances use pollutants with a tiny diameter to tackle particular concerns with the skin. Nanoparticles can facilitate the transport of peptides, antioxidants, and other anti-aging compounds.

6. Sunscreen: Broad-spectrum UV protection is supplied by sunscreens including nanoparticles such as zinc oxide and titanium dioxide nanoparticles, and these are chosen because they leaving no invasive or apparent residue on the skin. (Martel-Estrada et al., 2022) The use of nanomaterials in the development and production of cosmetics expands back many centuries and is evidence of human ingenuity in the field of personal care and beauty.

Women in ancient cultures, especially those who lived in places like Egypt and Asia, used nanoparticles made from precious metals like silver and gold as nail colors, according to historical documents. These early cosmetics used metal particles that were very finely ground or suspended and had special optical features at the nanoscale. When applied to nails, these nanoparticles can create shimmering and iridescent effects, augmenting the wearer's visual enticement.

Also, throughout the Middle Ages, anti-aging products containing gold and silver nanoparticles were created. These formulations took use of the presumably advantageous qualities of these precious metals, although the fact because our understanding of nanotechnology was not as grown as it is now. The skin-improving and restoring properties of gold and silver nanoparticles led to their development as features in skincare and cosmetic products at the point in time.(Gate L et al.,2017).

Advantages in terms of appearance, security, and health. Nanoparticles in cosmetics have a dual nature; they may have negative effects on health in addition to cosmetic benefits. Because we don't know how harmful they will be, their special features, resulting from nanoscale size, present safety issues. It is still difficult to determine the safety of nanomaterials, and it is quite troubling to think of nanoparticles getting into the circulatory system during manufacture or application. Potentially harmful outcomes from such exposure highlight the necessity of thorough safety evaluations in order to ensure the proper use of nanoparticles in cosmetic products and to allay customer concerns (Riaz et al., 1995). By developing regulatory standards, the FDA in the US has highlighted how important it is for maintaining the safety of nanomaterials in cosmetics. These regulations highlight preserving the integrity and safety of cosmetics. The FDA needs two essential pieces of data to evaluate the safety of nanoparticles in cosmetics. Firstly, it is essential to give thorough explanations of the substance's characteristics, especially when it is present in its nanoscale form. Information on the substances utilized, the finished cosmetic items, any interactions with biological systems, and the nature of any related pollutants are all included. In order to address concerns about problems like poisoning, pollution, and allergies, as well as to ensure customer safety and product quality, this thorough information is essential. Having accurate and readily available information of this kind is absolutely essential for resolving issues with poisoning, pollution, and allergies. The second element, which is essential to the assessment of cosmetics with nanoscale dimensions, consists of toxicological data that covers an extensive analysis. This evaluation should encompass possible skin irritation, allergies, photosensitivity, and photoallergic responses in addition to acute, chronic, and sub-chronic systemic toxicity. This thorough assessment is essential to protecting the security and wellbeing of customers, giving them the information they need to make wise decisions and minimizing any potential health hazards related to these items (Effiong et al., 2020). It is essential to understand that overall exposure to nanoparticles from similar products or prolonged use of particular items can pose a significant toxicological risk in addition to the thorough evaluation for acute, chronic, and sub-chronic systemic toxicity, photo irritation, potential skin irritation, allergies, and photoallergic reactions. More

information must be collected in order to address these issues properly. This information needs to include an analysis of the impacts on genotoxicity, foetal toxicity, carcinogenicity, and reproductive health. For a comprehensive knowledge of the possible dangers related to nano-sized cosmetic products, several safety evaluation factors are essential. Informed decisions that priorities safety and reduce possible health risks may be made by regulatory agencies, producers, and consumers by completing extensive analyses in these areas. This encourages the responsible use of these goods and protects the public's health (Bassetti et al., 2020).

FORMULATIONS OF NANOPARTICLES IN COSMETICS

Nanomaterials are substances having a size of at least one nanometer with uniquely different physical and chemical properties. For a very long period, these ingredients have been utilized often in the cosmetics industry. Cosmetics made from nanomaterials have greater benefits than little items. These particles' large surface areas allow for great bio absorption, effective distribution across barriers, bioavailability, and prolongation of the effects of the substance. To avoid the toxicity that goes along with the therapeutic concentration, caution should be used (Biswas & Wu 2005; Biswas et al., 2023). certainly, the various sizes and forms of cosmetic nanomaterials have special features that influence their use for particular kinds of cosmetics. The many nano-based preparations utilized in the cosmeceutical business are represented visually in Figure 1. These formulations are specifically created to take use of the distinctive properties of nanomaterials to improve the performance and potency of cosmetic products, making them more suitable for their intended uses in cosmetic and skincare (Ahmad et al., 2018).

Nano emulsions. The uniform distribution of liquid droplets as small as a nanometer occurs in a nano emulsion inside a continuous phase. These tiny droplets are an ideal choice for releasing active chemicals in cosmetic products because of their large surface area. This unique feature improves the effectiveness of skincare and cosmetic formulations by providing the efficient absorption of important components and giving the products attractive sensory qualities (Jaiswal et al., 2015). Nano emulsion ingredients are frequently accepted as safe for use in cosmetic production. Because of their exceptionally small droplet sizes, nano emulsions are prized for their outstanding efficacy, stability, and transparency. They become a popular option in the cosmetics sector as a result, protecting the safety and quality of the products and improving user experience through formulas that look good and work well (Aziz et al., 2019).

Nano capsules. The use of nano capsules has resulted in significant improvements for the cosmetics sector. These minute particles, which frequently range in size from 10 to 1000 nanometers, are essential to the creation of cosmetic products. They operate as carrier systems, covering active chemicals to protect them from degradation. This not only increases the long-term stability of these substances but also protects their availability in cosmetic goods for the intended use(nutan badhe et al.,2023). Thus, nano capsules have developed into useful instruments for improving the efficacy and durability of skincare and cosmetic compositions (Bassetti et al., 2020). In addition to simple protection, nano capsules allow for a controlled release of the substances they contain, resulting in a slow and long-lasting impact. The targeted distribution and increased efficacy of cosmetic products are made possible by the specific management of component release. Additionally, nano capsules improve the absorption of active substances into the skin, hence enhancing their therapeutic benefits. In conclusion, the use of tiny capsules in cosmetics shows their ability to improve product performance and deliver the required aesthetic results accurately and effectively (Wu et al., 2020).

Liposomes. A lipid bilayer, primarily made of phospholipids and cholesterol, makes up the spherical capsule known as a liposome. These lipid atoms self-assemble into a hollow, closed structure that encircles an aqueous (water-based) core. Simple tiny structures called liposomes are employed in a variety of industries, such as medicine and cosmetics, since they can efficiently encapsulate and distribute molecules. Liposomes are flexible instruments for medicine delivery, skincare products, and other uses because of their lipid-based membrane, which enables them to encapsulate both hydrophilic (water-soluble) and hydrophobic (water-insoluble) molecules (Sharma et al., 2018). In fact, the unique structure of liposomes enables the integration of lipophilic medications inside their lipid bilayers and hydrophilic drugs within their watery compartments. Liposomes are an effective medicine delivery technique because of their adaptability in drug encapsulation. The bilayer of lipids of liposomes may also fuse with cell membranes, allowing for specific administration of active ingredients and the breakdown of their contents. Because of their capacity for quick and accurate drug delivery, liposomes are a good option for various therapeutic applications (Alexandre et al., 2013)).

Solid lipid nanoparticles (SLNS). Small lipid-based droplets called Solid Lipid Nanoparticles (SLNs) are surface-active agent-stabilized. They are great at preventing the degradation of encapsulated active chemicals and are essential for creating cosmetics with accurate ingredient distribution and improved skin penetration (Schreier et al., 1993). They are a flexible instrument in the creation of efficient and the moment skincare products since they also provide the extra benefits of increased moisturization and skin nourishing (Arora et al., 2012).

Niosome. Niosomes are flexible non-ionic surfactant particles made from disposable and safe materials that are used in medication administration. They stand out from other colloidal carriers due to their outstanding stability and cost-effectiveness. They have a variety of uses in the exact and controlled administration of medications via a variety of routes, such as oral, topical, parenteral, and ophthalmic administration. As a result, niosomes are an essential element in pharmaceutical formulations because they provide effective, safe, and flexible drug delivery (Riaz et al., 1995). Niosomes were first used into cosmetics in the 1970s, which was a huge advancement for skincare and cosmetics. By releasing a niosomal lotion in 1986 to fight the effects of growing older, Lancome made a significant contribution and showed the early possibility of niosomes in the beauty industry(nutan badhe et al.,2023) Niosomes have now demonstrated their adaptability in several sectors, acting as vehicles for a wide range of applications. Haemoglobin delivery, cancer treatment, oral peptide medication administration, leishmaniasis treatment, enabling ocular drug delivery, and being a key component in cosmetic formulations are a few of these. Niosomes are flexible, making them useful instruments for developing medication and cosmetic delivery methods that may meet a wide range of applications (He et al., 2019). Around 12% of all the tiny particles used in cosmetics worldwide are made up of nano silver. The cosmetics industry frequently classifies these metallic nanoparticles, which are smaller than 100 nanometers in size, as mineral nanoparticles. They are significant components in many skincare and cosmetic products because of their tiny size and unique characteristics (Han et al., 2014). Shampoos, toothpaste, and acne treatments are just a few examples of the personal care items that frequently contain colloidal silver or silver nanoparticles as preservatives. They are often used in these products because they are efficient against a variety of germs and have potent antibacterial capacity. These are so a good option for preventing infections and assuring the security and lifespan of personal care product compositions (Ong & Nyam 2022). Investigating the special antifungal and antibacterial capabilities of nano silver and its related compounds has received a lot of study attention. These qualities are considered to be the result of silver ions being released, which have strong antibacterial effects. Gold nanoparticles, on the other

hand, have the potential to be used in cosmetics because to how well they carry and release medications. These nanoparticles are added to cosmetic chemicals to improve the end product's overall quality and effectiveness. It is a frequent practice to modify their characteristics through thiol linkages in order to optimize them for certain purposes. For instance, nano gold is regularly included into toothpaste and other easily accessible personal care items, where it is essential for aiding efficient dental hygiene practices (Chennakesavulu et al., 2018).

Nano-metals. Nanometals with outstanding antibacterial characteristics, such nano silver and nanogold, have become quite popular. Their use in items like toothpaste and perfumes has grown standard across several industries. Their amazing ability to prevent bacterial development, a feature greatly valued in personal care and hygiene products, can be credited for their widespread acceptance. As a result, compared to other nanoparticles, nano silver and nanogold have attained a significantly greater market value. They are important elements in these consumer items due to their effectiveness, strength, and adaptability in resolving hygienic issues, which has increased need and increased market pricing (Drulis-Kawa et al., 2010).

COSMETICS AND NANOTECHNOLOGY

It's true that a lot of everyday experiences of individuals are greatly influenced by cosmetics. A typical grownup typically uses nine cosmetics daily on average. The results emphasize the fact that and widely used cosmetics are, making them one of the most regularly used consumer goods ever. Cosmetics are enticing for the reason that they can meet people's intrinsic desire to appear and feel their best. Cosmetics may make a person feel more appealing, promote self-confidence, and give them a more youthful appearance. They provide people a way to express themselves and also allow them to try on various looks and patterns. The cosmetics are frequently used for function aims such as skin protection via the use of sunscreen, cleanliness keeping through the use of skincare products, and obscuring flaws with the use of makeup. Given that they meet both practicality and aesthetically pleasing objectives, cosmetics are popular and widely used because they assist people show themselves in the best possible perspective. (Farwin & Ruzaik 2021). Whenever defined broadly, the phrase "cosmetics" refers to many different kinds of chemicals applied to the body, typically the skin, hair, or nails, with the primary goal of improving or changing one's physical appearance. These personal care products serve a wide range of activities, from washing and moisturizing to improving attraction and keeping the body's exterior properties. The formulation of products like cleansers and face washes, which efficiently remove dirt, oil, and harmful substances from the skin, promoting cleanliness and giving the impression of freshness and radiance, is part of the scrubbing element of cosmetics.

Another basic purpose for cosmetics is to moisturize. Moisturizers, lotions, and creams are samples of products that are tailored to hydrate and nourish the skin, keeping it smooth, supple, and well-moisturized while also promoting a healthy and attractive complexion. Cosmetics are vital for enhancing one's inherent attractiveness. This sort of cosmetics involves items like foundation, lipstick, eyeshadow, mascara, and blush that are expertly crafted to emphasize certain features, provide a variety of looks, and enhance confidence, enabling people to express their creativity and distinctive characteristics. Some cosmetics act as shields to safeguard the body's radiating properties(nutan badhe et al.,2023). For example, sunscreens and protective creams are meant to protect the skin and hair from external factors including damaging UV radiation and toxins from the environment. These goods contribute to the life and longevity of the body's outer features by maintaining their well-being and look. (Salvioni et al., 2021) A wide range of offerings aimed at different facets of personal care and grooming are included in the realm of cosmetics. These goods take on a variety of forms, such as personal care products, creams, lotions, hair care items, smells, and nail paints. They partner up to raise standards for general grooming and personal

purity, encourage self-care behaviors, as well as enhance aesthetic appeal. Products for personal care within the broader category of cosmetics are typically classified into several categories, which include Makeup, skincare, haircare, fragrances, nail care , oral care . (Coelho SG et al., 2016).

1. Cosmetics for skin care, such as moisturizing and cleansing products.
2. Hair-care cosmetics such as aesthetic agents, hair colors, conditioners and shampoo may be used.
3. Makeup for the face, comprising lipstick, powder, mascara, and foundation.
4. Nail care goods, such as nail polish and paint removers.
5. Items with a fragrance, including cologne, aftershave, deodorants, and fragrances.
6. Sunscreens and other UV protection measures. This idea makes it clear that cosmetics are not the same as medications.

In fact, there is a type of cosmetics called "cosmeceuticals" that differs from traditional cosmetics. Because they contain substances with biological effects or moderate therapeutic qualities similar to those found in medicine, makeup is sometimes referred to as "cosmeceuticals." These items sometimes act as a bridge between cosmetics and meds since they are designed to bring some specific benefits to the skin.

Cosmeceutical products may include ingredients like vitamins, antioxidants, peptides, and botanical extracts, among others, which can have a notable impact on the skin's health and appearance. Some of the common benefits associated with cosmeceuticals include:

1. **Anti-Aging:** Compounds frequently work to reduce the visibility of wrinkles, fine lines, and sagging skin. Anti-aging cosmeceuticals typically contain ingredients like as retinol and hyaluronic acid.
2. **Skin Brightening:** These products may contain ingredients like vitamin C or niacinamide, which can help brighten the skin, reduce hyperpigmentation, and improve overall skin tone.
3. **Moisturization:** Cosmeceuticals may fully hydrate and exfoliate the skin, facilitating in the ongoing preservation of a silky healthy complexion.
4. **Acne Treatment:** Some cosmeceuticals include ingredients like salicylic acid or benzoyl peroxide to address acne and blemishes.
5. **Sun Protection:** Cosmeceutical sunscreens offer both UV protection and skin benefits, such as antioxidant properties.
6. **Skin Repair:** Ingredients like peptides and growth factors may aid in skin repair and regeneration.

Within the industry, it is regular practice to use the terms "cosmeceutical" and "cosmetics" indiscriminately in diverse situations. These phrases have been frequently employed by skincare scientists, healthcare providers, product manufactures, and researchers to promote user endorsement of cosmetics and to make it easier to identify goods in the beauty and skincare markets. When a cosmetic product contains products that may have therapeutic advantages but is still categorized as a cosmetic rather than a pharmaceutical, the term "cosmeceutical" may be used to emphasize this. The difference is meant to draw attention to the product's ability provide benefits beyond exclusively cosmetic improvements. It's crucial to keep in mind that the terminologies and laws governing the usage of "cosmeceuticals" might vary by location and sometimes are not well defined. This phrase may be used more freely in certain nations while others may have explicit regulations directing its use.

Regarding nano cosmeceuticals, these are cosmetics which include nanoscale components in their compositions, such as nanoparticles. Particularly in skincare, hair care, lip care, and nail care products, these nanoscale parts can improve the efficacy and performance of the product. The distribution, absorption, and general product quality of nano cosmeceuticals are enhanced by the special characteristics of nanoparticles. Despite the vocabulary and classifications used in the beauty products industry might vary, it is crucial that customers are aware of the specific products they use and comprehend the reasons for which they are designed. Making the best product choices for unique skincare concerns might benefit from advice from dermatologists or skincare specialists.

Nanocosmeceuticals' regulatory characteristics.

The regulatory landscape for nano cosmeceuticals, which are cosmetic products containing nanoscale ingredients with purported therapeutic benefits, varies by country and region. Different regulatory agencies have developed guidelines and requirements to ensure the safety and efficacy of these products. Here are some of the key regulatory features of nano cosmeceuticals:

1. **Ingredient Safety Assessment:** Manufacturers of nanomaterials used in cosmeceuticals are frequently required by regulatory organisations to complete safety analyses. This involves analysing possible dangers connected to the ingredient's nanoscale characteristics, such as its size, shape, and surface area. Toxicology studies, skin penetration evaluations, and other pertinent testing must be used by manufacturers to demonstrate the safety of their ingredients (Gupta et al., 2022; Mohd-Setapar et al., 2022)
2. **Labelling standards:** In order to alert consumers to the presence of substances at the nanoscale in cosmeceuticals, stringent labelling standards are frequently used. On the product label, phrases like "nano" or names of particular ingredients with nano characteristics may be used (Konstantinova et al., 2017)
3. **Claims and Advertising:** Regulatory agencies monitor the claims and advertising associated with nano cosmeceuticals. Manufacturers must ensure that their product claims are truthful, not misleading, and supported by scientific evidence. Exaggerated or unverified claims about the therapeutic benefits of nanoscale ingredients are typically not allowed.
4. **Safety Data Requirements:** Manufacturers may be required to provide safety data related to nanoscale ingredients, including studies on skin penetration, irritation, sensitization, and other potential adverse effects. This information helps regulatory authorities assess the safety of the product (Bassetti et al., 2020)
5. **International Harmonization:** Efforts are underway to harmonize regulations for nanomaterials used in cosmetics at the international level. Organizations like the International Cooperation on Cosmetic Regulation (ICCR) work to align regulatory approaches to ensure consistency and safety across different regions.
6. **Post-Market Surveillance:** Regulatory agencies often engage in post-market surveillance to monitor the safety and performance of nano cosmeceuticals once they are on the market.

As the cosmetic business, academic research, and consumers equally, providing the safety of nano cosmetics is essential. The ingestion and skin contact are in fact two additional ways to be exposed to nano cosmetics. Many

regulatory organizations have created suggestions and guidelines to ensure the safe use of nano cosmetics in order to address these safety issues. The prevention of any potential adverse side effects related to the use of nano cosmeceutical goods is made possible by these guidelines, which are helpful for both makers and customers. In order to ensure the appropriate and safe use of nano cosmetics and protect the health and welfare of consumers, it is crucial to carefully abide by these suggestions. For regulatory authorities, business, and academia to keep current on new safety issues and changing standards of practice in the area of nanotechnology in cosmetics, continual research and collaboration are also essential (Alshawwa et al., 2022; MohdSetapar et al)

Effects of nanoparticle use in cosmetics on human health

A number of concerns are raised by the inclusion of nanomaterials in cosmetics, especially in light of their accidentally penetration of the skin and bloodstream. It has been shown that sunscreen products with nanoparticles, such as zinc oxide and titanium dioxide, which generally have a size range of 10 to 200 nanometers, can accidentally enter healthy skin and cause damage. This highlights the necessity for thorough toxicological analyses, regulatory supervision, and safety assessments that account for both intended and unforeseen effects. Promoting consumer protection and openly disclosing any dangers remain important in the dynamic world of nanotechnology in cosmetics (Raj et al., 2012). Actually, there are serious worries regarding the possible neurotoxic and cytotoxic consequences of nanoparticles in cosmetics. Zinc oxide nanoparticles have shown neurotoxic effects in studies on mouse brain stem cells, raising concerns regarding their safety in cosmetic goods. Additionally, cytotoxicity has been observed in titanium dioxide nanoparticles, suggesting a possibility for cell damage or death. These results underline the necessity of comprehensive and exacting toxicological evaluations of nanoparticles used in cosmetics. To guarantee that cosmetic items don't pose threats to human health, regulatory bodies, producers, and researchers must keep looking into the safety profiles of these nanoparticles. For customers to make educated decisions and for the cosmetics sector to priorities product safety, open communication of such discoveries is essential (Subramaniam et al., 2019). Recent studies have shown that titanium dioxide nanoparticles can cause sertoli cells to undergo autophagy and necrosis, which has a detrimental effect on sperm production and testicles anatomy in Zebra fish (Kotil et al., 2017). The greater penetration of nanoparticles into the skin and circulation can be facilitated by a number of circumstances, including skin diseases including eczema, acne, wounds, psoriasis, and exposure to UV radiation. When items containing nanoscale chemicals are produced, used, recycled, or disposed of, the workplace may be exposed to nanoparticles. Compared to micronized particles, nanomaterials pose a greater danger because of their ability to enter live cells and tissues due to their smaller size. Consequently, to address these hazards and enable the safe use of nanomaterials in goods, protecting both human health and the environment, comprehensive safety evaluations, strict regulatory monitoring, and occupational safety measures are needed. Nanomaterials can be ingested, inhaled, or absorbed via the skin, which raises questions regarding the possible health implications for people. Environmental concerns are also very important since it is possible for nanomaterials to be released into the air, water, or soil when they are produced, used, or disposed of in significant amounts. Antibacterial nanoparticles, for instance, may interfere with the beneficial bacterial systems that are present in natural environments. Additionally, certain nanomaterials have the ability to bond to airborne contaminants like cadmium or petrochemicals and transmit them over great distances. To protect both human health and the environment, it is crucial to thoroughly evaluate any dangers related to nano cosmetics throughout their entire lifespan, from creation through use and disposal (Effiong et al., 2020).

CONCLUSIONS

A highly developed area of study with clear benefits for the cosmeceutical sector is nanotechnology. The sector, which is based on nanotechnology, is expanding quickly and has the potential to completely transform the cosmeceutical industry. Nanoparticles are already used in many items on the market.

However, in order to evaluate these materials' possible toxicity, it is critical to do in-depth study to comprehend the health consequences of these substances, particularly when applied to the skin. Discussions and debates on the safety of nanoparticles in cosmetics continue, highlighting the necessity for in-depth research and clear knowledge in this developing industry. It is essential to ensure the safety of nanotechnology in cosmetics. Nanoparticles should go through real-life testing to determine their safety before being permitted for usage in the manufacture of cosmetics. Once determined to be safe, these compounds may be made available for use with the proper product labelling and implementation of control measures. Additionally, users of nanoparticle-containing cosmetics should alert the appropriate authorities right once if they have any odd responses. The supervision and regulation of safe items on the market, which will eventually improve consumer safety in the cosmetics sector, depend heavily on this reporting method. To guarantee product safety and transparency, manufacturers, regulators, and consumers work together.

FUTURE SCOPE

In fact, the cosmetics and skincare industries have recently undergone a revolution thanks to the use of nanoparticles into cosmetic products. Significant improvements in product formulation and distribution brought about by nanotechnology have enhanced effectiveness and user experience. Consider the following important factors when using nanoparticles in cosmetics:

1. **Enhanced Skin Penetration:** Nanoparticles may penetrate the top layer of skin more efficiently than bigger particles, generally with diameters between 1 and 100 nanometers. This improved penetration makes it possible for active substances to be delivered to deeper skin layers where they can be more useful in treating a variety of skin issues.
2. **Precise Ingredient Distribution:** Nanoparticles offer a way to uniformly and accurately distribute active ingredients in cosmetic products. As a consequence, substances are applied consistently, guaranteeing that every area of the skin benefits as intended.
3. **Stability of the Product:** Nanoparticles can extend the shelf life and stability of cosmetic formulations. These chemicals are less prone to decay as a result of exposure to light, air, or other environmental variables since sensitive components are enclosed within nanoparticles.
4. **Advancements in sunscreens:** Nanotechnology has had a significant impact on the creation of sunscreens. Nanoscale zinc oxide and titanium dioxide particles, for instance, can offer UV protection that is effective without leaving an unsightly white cast that is sometimes associated with conventional sunscreens.
5. **Anti-Aging and Skin-Brightening Products:** Nanoparticles are used in anti-aging and skin-brightening formulations to target specific skin concerns. They can deliver ingredients like antioxidants, peptides, and vitamins more efficiently, promoting collagen production and reducing the appearance of fine lines, wrinkles, and dark spots.
6. **Improved Aesthetics:** Nanoparticles can enhance the texture and feel of cosmetic products. They can make creams and lotions feel smoother and less greasy while improving the spreadability of makeup products.

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