Chapter 5

Emerging Trends of Nanotechnology in Cosmetics

Garima Nagpal1*, Rashi Chaudhary2, Ratiram G Chaudhary3 and N.B. Singh4,5
1Department of Environmental Sciences, Sharda University, Greater Noida, India
2Department of Life Sciences, Sharda University, Greater Noida, India
3Post Graduate Department of Chemistry, S. K. Porwal College, Kamptee-441001, India
4Department of Chemistry and Biochemistry, Sharda University, Greater Noida, India
5Research Development Cell, Sharda University, Greater Noida, India
*garima.nagpal@sharda.ac.in

Abstract
Cosmetics attract most age groups from teenagers to old age. Cosmetic goods now contain a variety of nanoparticle and nanomaterial types. Nano cosmeceuticals have changed the era of cosmetics as they have advanced delivery mechanisms with task specifications. They are used in nail, hair, lip, and skin care products by cosmetic giants including Estee Lauder, L’oreal, Nivea, Zelens, and Derma Swiss, etc., and have patented the use of dozens of "nanosome particles." The global market for cosmetics using nanotechnology is worth millions of dollars and increasing at 7.14% annually. Liposomes, niosomes, nanostructured lipid carriers, solid lipid nanoparticles, gold nanoparticles, nanoemulsions, and nanosomes are novel nanocarriers that are now used in a variety of cosmeceuticals for drug delivery to achieve site specification, improved stability, biocompatibility, extended action, and increased drug-loading capacity. In this chapter use of various nanocarriers in cosmetic applications with their safety concerns will be discussed.

Keyword
Nanomaterial, Nanotechnology, Nano Cosmeceuticals, Cosmetics

Contents
Emerging Trends of Nanotechnology in Cosmetics.................................................127
1. Introduction........................................................................................................128
2. Nanotechnology in cosmetic industry ...............................................................129
3. Classification of nanocosmeceuticals.................................................................131
### 3.1 Skin care

### 3.2 Hair care

### 3.3 Lip care

### 3.4 Nail care

### 4. Carriers in nano cosmetic systems

#### 4.1 Liposomes

#### 4.2 Niosomes

#### 4.3 Lipid nanoparticles

##### 4.3.1 Solid lipid nanoparticles (SLNs)

##### 4.3.2 Nanostructured lipid carriers (NLCs)

#### 4.4 Nanosphere

#### 4.5 Nanoemulsions

#### 4.6 Dendrimers

### 5. Green nanomaterials for cosmetics

### 6. Roles and mechanism of cosmetics

### 7. Toxicity of nanoparticles

#### 7.1 Ingestion

#### 7.2 Inhalation

#### 7.3 Dermal route

### 8. Safety assessment of nanomaterials in the cosmetic industry

### 9. Advantages and disadvantages of nanocosmetics

### Conclusions

### References

---

### 1. Introduction

Nanotechnology seek people's attention all over the world in recent years. It is a wide range of technology used to design, develop or manipulate materials at the nanoscale (size range of 1 – 100nm). At the nanoscale, there is a change in the characteristics of materials, which results in the surface-to-volume ratio rising, the number of particles present in unit weight, and the quantum confinement effect [1]. These exclusive properties of nanoparticles make them fit for various industries including household appliances, agriculture, pollutant removal, foods, communication, medical, transportation, military, cosmetics, and cosmeceuticals [2]. The substantial increase in the customer’s interest and need for better
performance, alluring appearance, retention, and safety has resulted in the expansion of formulations in cosmetics [3].

In 1961, Raymond Reed, a founding member of the US Society of Cosmetic Chemists, invented the term "cosmetics." Cosmetics are the substances or mixtures which come in direct interaction with the human body's external components. They are mainly used for changing the look, eliminating body odors, longer persistence of color, etc. [4]. Civilization has been using cosmetics for centuries. Western women began using cosmetics in secret using domestic goods in the late 19th century, and by the early 20th century, there was no longer any need for concealment. By the twenty-first century, cosmetics were widely used, and as technology advanced, creative cosmetic compositions were created by using the newest techniques [5]. Cosmetics with physiologically active ingredients that have therapeutic effects on the surface applied are known as cosmeceuticals. These are used in cosmetics because they purport to improve appearance. Between medications and personal care items, there is a gulf called cosmetics. Cosmeceutical products are used to treat a variety of disorders, such as hair loss, wrinkles, photoaging, skin dryness, dark spots, uneven skin tone, hyperpigmentation, and others. They, therefore, have an observable therapeutic effect on the skin [6].

The cosmetics business started utilizing nanotechnology to innovate and improve the quality of active components. There are a large number of factors including drug composition, polymers, additives, component interactions (physical or chemical), and manufacturing process, which regulate the drug release from carriers. Nano cosmeceuticals allow the regulated release of active compounds. They prolong perfumes, make them last longer, and boost the effectiveness of sunscreens by enhancing UV protection. Their use in hair care preparations includes hair fall treatment and avoiding hair from going grey. The surface area is boosted by having very small particle sizes, which enables the bitter of these active substances into the skin [7].

Nevertheless, some of these nanomaterials have the potential to harm the environment or human tissues and organs. To counter the adverse effect, natural or biodegradable substances were used for the framing of nanomaterials without compromising their performance. In this chapter advantages and disadvantages of nanoparticles in cosmetics and their utilization and patent by cosmetic giants will be discussed. The chapter gives a brief outline of the use of Nano cosmeceuticals in the formulation of cosmetics and their possible benefits followed by the mode of action of different carriers in Nano cosmetic systems. Later the chapter highlights the green nanomaterials in cosmetics and the mechanism of action of Nano cosmeceuticals. It also covers the various facets of how nanoparticles affect cosmeceuticals and human health.

2. Nanotechnology in cosmetic industry

It would be an uphill battle to set a timeframe for the origin and use of cosmetics because they wish to stay and appear decent as such has been as old as man itself and it is the key driving force for cosmetic use. Egyptians were credited with cosmetic use around 4000
BC. Later Americans, Greeks, Chinese, Romans, and Japanese were also reported to use cosmetics. Close to the turn of the 20th-century household items were used as cosmetics. By the 20th century, cosmetics were used without seclusion. In the 21st century technological integration has developed inventive cosmetic formulations that are used immensely nowadays [8]. When these cosmetic products are integrated with biologically vital therapeutic additives to escalate appearance are called Cosmeceuticals [9]. They are used in the treatment of hyperpigmentation, wrinkles, uneven complexion, photoaging, skin dryness, dark spots, hair damage, etc. Several surveys have exhibited that nanosized materials are now employed by all leading cosmetic fabricators in their various products. Many streams of chemical sciences have been changed to the pharmaceuticals as well as get linked with nomenclature, Nano cosmetics. A large number of metals (AgNPs, AuNPs), metal oxide nanoparticles (TiO2NPs, ZnO NPs, Fe2O3NPs), and carbon-based NPs are used in the formulation of cosmetics [10–12]. All the cosmetic giants including Estee Lauder, L’oreal, Nivea, Zelens, Derma Swiss, etc. are using nanoparticles in the formulation of cosmetics (Table 1-5). The industry for nanotechnology-based cosmetics is worth millions of dollars worldwide. The biggest cosmetics corporation in the world, L'Oreal, is investing a significant portion of its earnings in nano patents and has already earned patents for numerous "nanosome particles" [13]. TiO2 has properties of UV filtration (UVA and UVB filter) and is thus mainly used in the fabrication of products like sunscreens and moisturizers. It is also utilized in the production of lip balm, foundation, and daycare cream since it shields the skin from the damaging effects of UV radiation. Proctor and Gamble, Dermatone, Colore science, and Boots are some giants using TiO2 and ZnO as nanoparticles. Nanoparticles made of silver and gold have anti-bacterial and anti-fungal characteristics [14].These nanoparticles are used in manufacturing deodorants, sanitizers, and anti-aging creams. Lancôme is one of the leading cosmetic manufacturers using nanocapsules of vitamin E in moisturizer with the name Hydra Flash Bronzer Daily Face moisturizer and it declares for natural, healthy glowing skin. Similarly, one of the hand sanitizer manufacturing company, Evolut claim high effectiveness for skin protection and disinfectant as they use silver nanoparticles for antibacterial properties. Nail polishes containing nanomaterials have been patented as they are not damaged easily, are long-lasting, and are resistant to scratches [15]. One of the nail polish manufacturers Nano lab corp has used lacquer containing nanoparticles which make its application easy and protect it from shock, scratch, or crack [16]. Similar to this, a variety of products with distinct qualities of nanoparticles (nanogold and nanosilver) integrated into nail cleaning items are accessible in the market [17].

The fabrication of beauty treatments using nanotechnology has greatly increased in recent years as it results in the long-lasting fragrance of perfumes, sunscreens with UV protection, antiaging creams with prolonged dermal hydration, and more persistence of hair colors, etc. [6].
3. Classification of nanocosmeceuticals

The personal care industry's fastest-expanding sector is thought to be cosmetics. Products for caring for the skin, hair, lips, and nails comprise nano cosmeceuticals. Some of the classes in nano cosmeceuticals are shown in figure 1.

3.1 Skin care

Skincare products help skin function and texture by promoting collagen formation and fending off the damaging effects of free radicals. By preserving the keratin's healthy structural integrity, they get better well-being of the skin. ZnO and TiO₂ nanoparticles are the most effective minerals for skin protection and are used in sunscreen lotions. They allow the product to become less greasy, odorous, and transparent by penetrating the deeper layers of the skin [18]. SLNs, Nanoemulsions, Liposomes, and Nanosomes are widely used in the creation of moisturisers due to their capacity to build thin films of humectants and hold onto moisture for protracted periods of time. Products marketed as anti-aging Nanocosmeceuticals that incorporate nanocarriers show properties of collagen regrowth, skin rejuvenation, and forming and preserving the skin [19].

Figure 1. Nanocosmeceuticals Classes

3.2 Hair care

Shampoos, conditioners, hair growth accelerators, coloring agents, and styling treatments all fall under the category of hair Nano cosmeceuticals. The intrinsic qualities and distinct size of nanoparticles enable them to target the hair follicle, and shaft, and boost the amount of active substance.
The inclusion of nanoparticles in shampoos optimizes residing contact time with the scalp and hair follicles by generating a protective layer, which locks moisture within the cuticles [20]. Nano cosmeceutical conditioners are designed to add softness, sheen, silkiness, and gloss while improving hair detangling. Novel carriers such as liposomes, nanospheres, microemulsions, and niosomes have the primary purpose of texture and gloss restoration, healing damaged cuticles and making hair less brittle, glossy, and oily [21].

3.3 Lip care

The lip care line includes the use of lipstick, lip balm, lip gloss, and lip volumizer. Lip gloss and lipstick can contain a variety of nanoparticles combined to minimize trans epidermal water loss, soften lips, stop lip pigmentation, and keep lips colored for longer. Liposomes present in lip volumizer fill in lip wrinkles, moisturizes and define the lips, and improve lip volume [22].

3.4 Nail care

Products available for caring for nails that use nano cosmeceuticals are far superior to those that do not. The advantages of nail paints based on nanotechnology include greater toughness, quick-drying, more durability, crack resistance, and ease of application because of their elastic properties [23]. Amalgamating silver and metal oxide nanoparticles are used for the treatment of toenails as they have antifungal characteristics [24].

4. Carriers in nano cosmetic systems

Carrier technology, which offers an acute strategy for the distribution of active substances, is used for the delivery of nano cosmeceuticals. Different cutting-edge nanocarriers for the distribution of cosmeceutical products are seen in Figure 2.

Figure 2. Nano cosmeceutical carriers
4.1 Liposomes

The most common use for liposomes is in cosmeceutical products. They are membranous structures that are surrounded by a hydrophobic lipid bilayer and possess an aqueous core [25]. Since phospholipids make up the majority of the lipid bilayer in liposomes and are typically considered to be nontoxic substances, the likelihood of adverse consequences is decreased [26]. Liposomes encapsulate drugs and release their active elements gradually to prevent metabolic breakdown [27].

The transport of both hydrophilic and hydrophobic substances is possible using liposomes. They can be either multilamellar or unilamellar in structure, and they range in size from 20 nanometers to several micrometers [28]. Due to their distinct benefits, liposomes, which are versatile functional carriers, have found use in the cosmetics business, including an increase in cosmetic chemicals solubility, compatibility with human skin, decreased toxicity, and improved drug accumulation at the targeted site. The fact is that they frequently display regulated release kinetics while also guarding the medication against external degradation [29,30]. The cosmetics sector can use liposome-based Nano formulations to create antiperspirants, lotions, lipsticks, deodorants, moisturizers, and other beauty goods. Capture, an anti-aging cream introduced by Dior in 1986, was the first beauty product made with liposomes. Additionally, liposomes can be employed to transport active biomolecules like vitamins A, E, and K, as well as antioxidants like Coenzyme Q10, lycopene, and carotenoids. Liposomes aid in the skin's moisture as well. Lipid molecules like cholesterol and ceramides can be easily integrated into liposomes, which also aid in rebuilding the skin's epidermal layers [31,32]. Phosphatidylcholine, the primary component of liposomes, has been used in a variety of skin care formulations, including moisturizing creams and other products, as well as hair care formulations, including shampoo and conditioner, due to its softening and conditioning properties. Due to their compatibility with living tissues, biodegradability, and nontoxic properties, liposomes are utilized in numerous cosmeceuticals as they contain active components [33]. Vegetable phospholipids are utilized frequently for transdermal treatment and cosmetics as they contain large amounts of essential fatty acid esters. These phospholipids facilitate the entry of linoleic acid into the epidermis. It results in the improvement of skin within a short period as it improves the skin's barrier function and reduces water loss [34,35]. The distribution of flavors, phytonutrients, and vitamins from dehydrated compositions like antiperspirants, body sprays, deodorants, and lipsticks is now being worked on using liposomes. They are also utilized in sunscreen, anti-aging, deep moisturizing, cosmetics, and hair loss treatments [36]. Figure 3 [37] discusses several liposome advantages and disadvantages. The different commercial formulations are listed in Table 1 [31,38–40].
**Table 1. Formulations of liposomes**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Brand Name</th>
<th>Promoted by</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rehydrating Liposome Day Crème</td>
<td>Kerstin Florian</td>
<td>Moisturizing</td>
</tr>
<tr>
<td>2.</td>
<td>Liposome Face &amp; Neck Lotion</td>
<td>Clinicians Complex</td>
<td>Skin is nourished, and photoaging is avoided.</td>
</tr>
<tr>
<td>3.</td>
<td>Capture Totale</td>
<td>Dior</td>
<td>when paired with sunscreen, eliminates wrinkles, and dark spots, and provides a radiant look.</td>
</tr>
<tr>
<td>4.</td>
<td>Dermosome</td>
<td>Microfluidics</td>
<td>Demulcent</td>
</tr>
<tr>
<td>5.</td>
<td>Liposome face cream</td>
<td>Decorte</td>
<td>Demulcent</td>
</tr>
<tr>
<td>6.</td>
<td>Liposome eye cream</td>
<td>Decorte</td>
<td>moisturizes while firming and brightening the sensitive skin around the eyes.</td>
</tr>
<tr>
<td>7.</td>
<td>Natural progesterone liposomal skin cream</td>
<td>NOW Solution</td>
<td>keeping a healthy female balance</td>
</tr>
<tr>
<td>8.</td>
<td>Advanced night repair protective recovery complex</td>
<td>Estee Lauder</td>
<td>Skin regrowth</td>
</tr>
<tr>
<td>9.</td>
<td>Fillderma lips lip volumizer</td>
<td>Sesderma</td>
<td>Given more volume, wrinkles are filled in, the skin is moisturized, and the lips are outlined.</td>
</tr>
<tr>
<td>10.</td>
<td>Luminescence eye cream</td>
<td>Aubrey Organics</td>
<td>Solidification and anti-aging</td>
</tr>
<tr>
<td>11.</td>
<td>Russell organics liposome concentrate</td>
<td>Russell organics</td>
<td>Skin becomes more hydrated and rejuvenated, firmer, softer, and smoother.</td>
</tr>
</tbody>
</table>
4.2 Niosomes

When combined with or without cholesterol or similar lipids, hydrated nonionic surfactants, it results in the spontaneous formation of niosomes [41]. Niosomes are membrane-enclosed vesicles that are multilamellar or unilamellar, bilayer-organized surfactant macromolecules that can surround a mixture of solute and lipophilic substances in water [42]. Small unilamellar vesicles, multilamellar vesicles, and large unilamellar vesicles have relative sizes of 0.025–0.05 m, =>0.05 m, and 0.10 m [43]. The manufacture of Niosomes uses nonionic surfactants, polyoxyethylene alkyl ether, surfactants linked with steroids, as well as cholesterol as major constituents [44]. Niosomes are effective for delivering both hydrophilic and hydrophobic substances. Niosomes can be employed as a unique medication delivery mechanism for pharmaceuticals that are not readily absorbed [45]. It gives the drug encapsulation, which prolongs its time in systemic circulation and increases its penetration of the target tissue. Niosomes are an improvement over liposomes, which have drawbacks such as instability issues, high cost, and oxidation susceptibility [46]. Niosomes are utilized in cosmetic and skin care products because they can reversibly lower the horny layer's barrier resistance, which allows chemicals to penetrate the skin more quickly and reach live tissues. The nature of the encapsulated drug, the content of the membrane, and the hydration temperature are only a few of the many parameters that affect the creation of niosomes [47]. L'Oreal first created niosomes in 1970 through the study and creation of artificial liposomes.

Niosomes were created under the trade name Lancome and were given a patent by L'Oreal in 1987. There are many niosome cosmeceuticals products in the market, including anti-aging creams, creams for whitening and hydrating the skin, and shampoos and conditioners for restoring damaged hair [48]. Figure 4 [49–50] discusses several niosome benefits and drawbacks. Table 2 [10,51–52] discusses the usage of various commercially available goods.

**Figure 3. Positive and Negative aspects of liposomes [37]**
There are many noisome-based cosmetic formulations available for use in hair and skin care. In comparison to traditional liposomes and niosomes, Novasomes are a new development in liposomal technology. Novasomes have a central core surrounded by many bi-lipid layers (2-7) with a very high drug-loading capability. Drugs that are both

![Figure 4 Advantages and Disadvantages of Niosomes [49-50]](image)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Product Name</th>
<th>Marketed By</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Niosome + Perfect age treatment</td>
<td>Lancome</td>
<td>eliminates crease</td>
</tr>
<tr>
<td>2.</td>
<td>Niosome +</td>
<td>Lancome</td>
<td>wrinkle-reducing foundation cream, clean skin tone</td>
</tr>
<tr>
<td>3.</td>
<td>Anti-Age Response cream</td>
<td>simply man match</td>
<td>Crease reducing</td>
</tr>
<tr>
<td>4.</td>
<td>Identik Shampooing Floral repair</td>
<td>Identik</td>
<td>Shampoo for hair patch</td>
</tr>
<tr>
<td>5.</td>
<td>Identik Masque Floral repair</td>
<td>Identik</td>
<td>Masque for hair patch</td>
</tr>
<tr>
<td>6.</td>
<td>Eusu Niosome Maka Pom Whitening Facial Cream</td>
<td>Eusu</td>
<td>whitened skin</td>
</tr>
<tr>
<td>7.</td>
<td>Mayu Niosome Base cream</td>
<td>Laon cosmetics</td>
<td>Hydrating and lightening</td>
</tr>
</tbody>
</table>
hydrophobic and hydrophilic, as well as those that can interact with others, can all be delivered at the same time in various layers of novasomes [53]. They are made from a combination of monoesters of polyoxyethylene fatty acids, free fatty acids, and cholesterol (non-phospholipid surfactant). IGI laboratories, NOVAVAX, created the nova some technology, which includes this ground-breaking encapsulation method [54]. In comparison to liposomes and niosomes, novasomes have a substantially cheaper production cost and a high drug entrapment efficiency. These nanosystems are also more stable, remaining stable in a pH range of 2 to 13 and a temperature range of 0 to 100° C. Novasome offer tremendous potential in a variety of sectors, including the pharmaceutical, cosmetic, and agricultural industries. There are many nova some-based products in the merchandise, one of them is AcneWorx by Dermworx, which claim to treat acne with novasomes having salicylic acid [55]. Terconazone (TCZ)-containing novasomes was recently developed for the cure of newborn napkin candida albicans, and their curative efficacy was compared to that of traditional TCZ solutions. The nova some-based formulation was discovered to be more therapeutically efficacious than the suspension and to have a somewhat higher volume of skin deposition than the noisome-based formulation [54].

4.3 Lipid nanoparticles

4.3.1 Solid lipid nanoparticles (SLNs)

The first-generation lipoidal carriers, known as Solid Lipid Nanoparticles (SLNs), were created in the early 1990s. It consists of a solid lipid core in the centre that is disseminated in a water-based media with the help of surfactants. The medication and cosmetic ingredient can be loaded in the lipid matrix if it is hydrophilic, lipophilic, or poorly soluble in water. Due to the use of lipids that are both biocompatible and physiologically stable, SLNs avoid toxicity issues. Precipitation and high-pressure homogenization are the two main methods used to synthesize SLNs. SLNs carrying drugs within the shell result in blast release whereas SLNs carrying drugs within the core show sustained discharge [29,63]. SLNs are useful in cosmeceuticals and medicines. Because of their diminutive size and direct contact with the stratum corneum, active substances can penetrate the skin more easily [64].

Combining SLNs with sunscreen can improve photoprotection while minimising negative effects because they have UV-resistant qualities and function as physical sunscreens on their own [26]. SLNs have occlusive qualities that can be employed to raise the skin's water content and thus its hydration [65]. Since they spread out the release of scent over a longer length of time, SLNs are also used in perfume compositions and work best in day creams [66–67]. Because they are solid in nature and the mobility of the active molecules is limited, they have greater stability coalescence when compared to liposomes, which prevents leaking from the carrier [68–69]. Figure 5 [70–72] illustrates the benefits and downsides of SLNs. The usage of various commercially available products is listed in Table 3.
### Table 3: Marketed formulations of Solid Lipid Nanoparticle

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Product Name</th>
<th>Uses</th>
<th>Promoted By</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Phyto NLC Active Cell Repair</td>
<td>Skin firming, hydration, and reduction of tan</td>
<td>Sireh Emas</td>
</tr>
<tr>
<td>2.</td>
<td>Allure Eau Parfum Spray</td>
<td>Scent</td>
<td>Chanel</td>
</tr>
<tr>
<td>3.</td>
<td>Allure parfum bottle</td>
<td>Scent</td>
<td>Chanel</td>
</tr>
<tr>
<td>4.</td>
<td>Allure Body Cream</td>
<td>Lotion for Body</td>
<td>Chanel</td>
</tr>
<tr>
<td>5.</td>
<td>Sossion Facial Lifting Cream</td>
<td>Antiaging Cream</td>
<td>Soosion</td>
</tr>
</tbody>
</table>

#### ADVANTAGES
1. Controlled release of active substances and increased bioavailability
2. Increase skin hydration and penetration of drug
3. Better stability of unstable active ingredient
4. Easy large scale upgradability

#### DISADVANTAGES
1. Poor drug loading capacity
2. Low hydrophilic drug loading capacity due to partitioning effect
3. Unpredictable gelation tendency
4. High water content and better release can take place

---

**Figure 5** Advantages and Disadvantages of SLNs [70-72]

### 4.3.2 Nanostructured lipid carriers (NLCs)

Nanostructured lipid carriers are the second generation of lipid nanoparticles. To overcome the problems with SLNs, NLCs have been developed. The blend of liquid and solid lipids that make up NLCs gives them a less organized structure that allows them to hold more active ingredients in their pockets. NLCs are divided into amorphous, numerous, and imperfect subtypes based on structural variations, formulation techniques, and ingredients employed [73]. There is more scholarly and business interest now for NLCs during the last few years due to the reduced systemic side effects risk. NLCs in contrast to SLNs demonstrate increased medication loading for entrapped bioactive due to the compound’s twisted structure, which aids in expanding the area. Additional drawbacks of SLNs include lowering drug expulsion and particle concentration during storage. The creation of NLCs have solved these problems. They are created by physiological lipids that are biodegradable and exhibit very low toxicity [74]. They have many beneficial qualities, including enhanced skin moisture brought on by their occlusive abilities and their small size, which
guarantees close contact with the stratum corneum. There are improved UV protection systems with fewer adverse effects and steady drug integration during storage [75]. The first lipid nanoparticle-containing cosmetic product, Dr. Rimpler GmbH's NanoRepair Q10 cream, and serum, which offer greater skin penetration, was released onto the market in October 2005. More than 30 cosmetic items are on the market right now that contain NLCs [68,76]. Figure 6 [77-78] illustrates a few of NLC's advantages. Table 4 [79-80] contains a list of manufactured goods, their manufacturers, and their applications.

![Figure 6 Advantages of NLC’s](image)

**Table 4 List of marketed products, manufacturers, and uses of NLCs**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Product Name</th>
<th>Uses</th>
<th>Promoted By</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Olivenol Augenpflegebalsam</td>
<td>eliminates wrinkles, eye puffiness, and eye rings</td>
<td>Dr. Teiss/Medipharma cosmetics</td>
</tr>
<tr>
<td>2.</td>
<td>Olivenol Anti Falten Pflegekontrat</td>
<td>skin tightening and wrinkle prevention</td>
<td>Dr. Teiss/Medipharma cosmetics</td>
</tr>
<tr>
<td>3.</td>
<td>Regenerations Cream Intensive Ampoules</td>
<td>smoothest wrinkles and encourages cell regeneration</td>
<td>Scholl</td>
</tr>
<tr>
<td>4.</td>
<td>Swiss Cellular White Illuminating Eye Essence</td>
<td>eliminates discoloration and darkness under the eyes</td>
<td>La Prairie</td>
</tr>
</tbody>
</table>
4.4 Nanosphere

Nanospheres are spherical, core-and-shell-arranged particles. The medicine is entrapped, solution connected or encapsulated in nanospheres, where it is shielded from enzymatic and chemical deterioration. The medication is physically and evenly disseminated throughout the polymer matrix structure. The nanospheres makeup might be either crystalline or amorphous [81]. It holds great potential that this technology can transform chemicals with poor absorptivity, solubility, and physiological activity into the desired delivered medication. Different enzymes, DNA, and medications can be encapsulated inside nanospheres' centers [82].

The cosmetics industry uses nanospheres in skin protection yields to dispatch active chemicals to the skin's deep layers and dispatch their beneficial benefits to the skin's afflicted area more precisely and successfully. These tiny components aid in the defense against actinic aging. Nanospheres are increasingly being used in the cosmetics sector, particularly in skin care items including anti-aging, hydrating, and anti-acne creams [83]. Biodegradable nanospheres and nonbiodegradable nanospheres are the two categories into which nanospheres can be separated. Examples of biodegradable nanospheres include gelatin, starch, and albumin nanospheres, while polylactic acid is an example of a nonbiodegradable nanosphere. Figure 7 illustrates a pictorial illustration of nanospheres'
positive attributes and Table 5 lists the names of marketed product makers and their intended usage.

![Figure 7 Positive Aspects of Nanosphere [83]](image)

**Table 5 Formulation of Nanosphere**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Product Name</th>
<th>Uses</th>
<th>Marketed By</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cell act DNA Filler Intense Cream</td>
<td>It helps into Reduced firms Skin and wrinkles</td>
<td>Cell Act Switzerland</td>
</tr>
<tr>
<td>2.</td>
<td>Clear It! Complex Mist</td>
<td>Helps in Antiacne</td>
<td>Kara Vita</td>
</tr>
<tr>
<td>3.</td>
<td>Hydralane Ultra Moisturizing Day Cream</td>
<td>Helps in hydration and deep moisturizing</td>
<td>Hydralane Paris</td>
</tr>
<tr>
<td>4.</td>
<td>Fresh as a Daisy Body Lotion</td>
<td>Lotion for the Body</td>
<td>Kara vita</td>
</tr>
<tr>
<td>5.</td>
<td>Lip Tender</td>
<td>Moisturizing lips</td>
<td>Kara vita</td>
</tr>
<tr>
<td>6.</td>
<td>Nanosphere Plus</td>
<td>Antiwrinkle, antiaging</td>
<td>Dermaswiss</td>
</tr>
<tr>
<td>7.</td>
<td>Coryse Salome competence hydration ultra-Moisturizing Cream</td>
<td>hydrating cream</td>
<td>Coryse Salome Paris</td>
</tr>
<tr>
<td>8.</td>
<td>Eye tender</td>
<td>Antiwrinkle</td>
<td>Kara vita</td>
</tr>
<tr>
<td>9.</td>
<td>Nano salt moisture key</td>
<td>hydrating cream</td>
<td>Salvon</td>
</tr>
</tbody>
</table>
4.5 Nanoemulsions

Nanoemulsions are transparent or translucent liquids that have exceptional kinetic and thermodynamic stability. There are several different forms of nanoemulsion systems, including the oil in water (O/W), water in oil (W/O), and systems with many repeated layers i.e. oil/water/oil or water/oil/water. They differ in preparation technique used, which results in formulations with various consistencies, depending on the need, such as watery, creamy, or gel-like [83–88].

They are typically made by combining phase inversion, high-pressure homogenization, sonication, microfluidization, and other methods with co-surfactants and surfactants to give the formulation stability. Consequently, nanoemulsions have been widely used in the pharmaceutical business to create creams, lotions, and other cosmetic products. shampoos, gel-based products, sunscreens, sprays, lotions, deodorants, and lotions [89]. They are ideal cosmetic vehicles because of their attractive appearance and rich blending texture [90]. Figure 8 illustrates the merits of nanoemulsions. The nano gel Kemira is one of many systems based on nanoemulsions that have received patent protection. Similarly, to this, L’Oreal has obtained patents for nanoemulsions based on fatty acid esters and phosphoric acid [91-92].

![Figure 8 Merits of Nanoemulsions](https://example.com/figure8)

4.6 Dendrimers

A category of macromolecular organic chemical nanocarriers known as dendrimers comprises a central core and a web of long, symmetric branches that are joined to functional groups at their ends [93]. They are very small particles (2-20 nm), with a high permeability
rate, and can easily distribute the chemical present in the core. are employed in the formulation of nail polishes, hair care products, and cosmetics for the skin and hair that call for extremely thin films. The usage of dendrimers as vitamin conjugates has also been suggested in several kinds of research.

Additionally, they are employed as a carrier to improve the penetration of vitamins into the deep layers of skin. A large number of products based on dendrimers were patented by cosmetic corporations, like L’Oreal, Unilever, and Wella. Carbo siloxanexane dendrimer is patented which provides the skin and hair a glossy appearance and can withstand both water and oil [94]. Resveratrol-containing dendrimer formulations may also improve the substance's solubility, stability, and transdermal permeability; as a result, they may be used in anti-aging goose. The advantages of dendrimers are illustrated in Figure 9. In addition, they are allegedly utilized in the creation of shampoos, hair gels, lotions, spray gels, sunscreens, and anti-acne medications.

![Figure 9 Advantages of Dendrimers [95]](image)

5. **Green nanomaterials for cosmetics**

Green synthesized nanomaterials (NMs) have a lot of applications in various fields as they have amazing physicochemical properties. Moreover, green-synthesized NMs have outstanding advantages over chemically and physically synthesized NMs [96-97]. Green synthesized NMs are extensively used for antioxidant, medical, and clinical purposes like anticancer, derma-pharmaceutical, wound healing, anti-inflammatory, antiaging antimicrobial, and so forth [98-100]. Likewise, green NMs have an interesting application in the cosmetics industry. Nowadays, all over the globe, the different green NMs have been widely used for the cosmetic, treatment of cancerous and human skin diseases (Figure 10) [101]. Basically, for the last thirty years, green NMs have been utilized in the cosmetics business [102–104]. The cosmetics industry is a godsend for the country as it contributes huge economy.
The green NMs are always showing long-lasting effects, and increasing stability towards the uses of cosmetics. It is because of its high surface area and microporosity behaviors [105]. For instance, green NMs are currently used in eye-brow, anti-acne, lipsticks, sunscreens, nail polishes, makeup, hair protection, face-mask, anti-aging cream, etc (Figure 11). Moreover, it can use for body care, sun care, oral care, etc. The widespread uses of nanoparticles (NPs) in cosmetics products especially in skin care and sunscreens. L'Oréal et al. obtained nanotechnology-related patents which were based on green NMs for cosmetic applications. The most useful nano-ingredients like titanium oxide, zinc oxide, silica, and carbon black have been used for cosmetic preparation. Moreover, it is popularly known that the nanostructured TiO$_2$ NPs and ZnO NPs have great advantages over many product formations [107]. Even, microscale sizes of TiO and ZnO NPs are used as ingredients in various sunscreens ointment due to their wonderful absorption potential. Similarly, lipid nanoparticles are also one of the best remedies for skin treatment.

Other microscale lipid NPs can be employed for transdermal delivery. These types of drug delivery are used due to enhanced skin perforation with lower side effects [108]. Likewise, chitin-derived nanoparticles also have been used in the cosmetic and biomedical fields [109-110].
6. Roles and mechanism of cosmetics

There are two types of nanomaterials used in cosmetics: soluble nanoparticles also called biodegradable nanoparticles and insoluble or non-biodegradable nanoparticles. They serve as nanocarriers and increase the stability of products and permeability of active ingredients. They reduce the significant toxicity of the product and rashes on the skin. Applications in cosmetics and cosmeceuticals must include the physicochemical properties of nanoparticles as well as the fundamental interactions between human tissues (skin conditions). Passive diffusion is a prominent transport method for delivering active compounds via the skin. The only areas where nanoparticles can enter the body normally are through the skin pores and hair follicle openings [112].

Fig. 12 shows a schematic representation of the structure of the skin, which is a multilayered organ made up of the epidermis, dermis, and hypodermis, and table 6 represents the mechanism study of nanomaterials in cosmetics. The principal physical-chemical barrier to the penetration of bioactive chemicals is represented by the epidermis, which is the most superficial layer and is made up of a multilayered, tight epithelium. Keratinocytes make up the epidermis and are constantly moving from deeper to shallower layers. Desmosomes, adherent junctions, and tight junctions connect them and prevent chemicals from diffusing into the dermis.
These deeper layers contain blood vessels and innervations. According to their physical-chemical characteristics, molecules can pass through the epidermal layer in different ways. The molecular weight (MW) limit for molecules that can pass through the skin has been proposed as 500 Da [64]. Skin metabolism, its location, and tissue condition at the application site are additional factors that affect skin penetration. Other factors that affect skin penetration are how substances bind with the tissue structure and the degree of vehicle incorporation, and how substances interact with the tissue [113]. The latter is especially significant when used in cosmetics; in fact, the formulation can function via altering the polarity and lipophilic/hydrophilic ratio of substances as well as through mechanisms such as hydration and/or epidermal barrier adjustment. Phase behavior and viscosity also appear to have a significant impact on the partitioning of bioactive molecules [114-115].

Finally, it is important to note that the ultimate target determines whether a bioactive substance needs to partially pass the epidermis, penetrate the dermis, or enter the systemic circulation. Since the action is frequently limited to the top layers of the skin when used for cosmetic purposes.
### Table 6 Roles and mechanism study of nanomaterials in cosmetics

<table>
<thead>
<tr>
<th>S.No.</th>
<th>ROLES IN COSMETICS</th>
<th>TYPES OF NMs</th>
<th>MECHANISMS</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Antiaging</td>
<td>Fullerenes</td>
<td>Squalane's fullerene contains anti-aging properties. Extraordinary antioxidant activities of 2,4-nonadienal</td>
<td>[116-117]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Retinol</td>
<td>Amplify the manufacture of collagen, cell renewal, epidermal hyperplasia, and water content in the skin.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gold</td>
<td>The rigidity of skin is enhanced and rejuvenated by protein nanofiber gold.</td>
</tr>
<tr>
<td>2.</td>
<td>Whitening agent</td>
<td>Arbutin</td>
<td>A naturally occurring hydroquinone derivative that reduces age spots, dullness, and undesirable pigmentation by interfering with tyrosinase activity.</td>
<td>[121]</td>
</tr>
<tr>
<td>3.</td>
<td>Moisturizers</td>
<td>Hyaluronic acid</td>
<td>To prevent dehydration, a significant amount of highly viscous water is covered by hyaluronic acid.</td>
<td>[122]</td>
</tr>
<tr>
<td>4.</td>
<td>Concealer</td>
<td>Iron oxide</td>
<td>To conceal wrinkles and fine lines, it maintains transparency while diffusing light.</td>
<td>[123]</td>
</tr>
<tr>
<td>5.</td>
<td>Lip care</td>
<td>Gold-silica</td>
<td>The lips' thin line is kept from migrating or bleeding, and greasiness brought on by sebum secretion is inhibited by the pigments' homogeneous distribution.</td>
<td>[119]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gold and Silver</td>
<td>To prevent pigment deterioration and maintain color for a longer amount of time</td>
</tr>
<tr>
<td>6.</td>
<td>Sunscreen</td>
<td>ZnO and TiO</td>
<td>Create a skin barrier that is less irritative to deflect UVA and UVB rays Free radicals may develop as a result of photocatalytic activity.</td>
<td>[124-126]</td>
</tr>
<tr>
<td></td>
<td>Application</td>
<td>Nanomaterial/Technology</td>
<td>Description</td>
<td>References</td>
</tr>
<tr>
<td>---</td>
<td>-------------</td>
<td>-------------------------</td>
<td>-------------</td>
<td>------------</td>
</tr>
<tr>
<td>7.</td>
<td>Delivery active ingredients</td>
<td>Liposomes</td>
<td>Able to interact with cell membrane bilayers to promote delivery and discharge. Capable of distributing both hydrophobic and hydrophilic chemicals and protecting the encapsulated medications from the environment.</td>
<td>[29,78,127]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ceramides</td>
<td>The maintenance and construction of the skin's water permeability barrier. Reduce aging signs like dryness, lines, and wrinkles.</td>
<td>[128]</td>
</tr>
<tr>
<td>8.</td>
<td>Antibacterial agent/ skin cleanser</td>
<td>Ag and metal oxides</td>
<td>By cleaning/infecting wounds, beauty soap can treat decubitus, gangrene, pimples, and acne. Shown bacterial activity against gram-positive and negative bacteria.</td>
<td>[129]</td>
</tr>
<tr>
<td>9.</td>
<td>Dental care</td>
<td>Calcium fluoride</td>
<td>Preventing the brain from receiving pain signals by a long-lasting remineralization.</td>
<td>[130]</td>
</tr>
<tr>
<td>10.</td>
<td>Hair care</td>
<td>Liposome</td>
<td>Change the color of the hair follicle's melanin by using the bulge area. Hair color with a long-lasting impact and little toxicity.</td>
<td>[29,131]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dendrimers</td>
<td>Improved tactile sensitivity, glossiness, features of water resistance, sebum resistance, and hair adhesion.</td>
<td>[132-133]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silicone</td>
<td>Capable of diffusing into hair fibers to increase lubrication, gloss, and moisture.</td>
<td>[21,134]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nanoemulsions</td>
<td>Rejuvenate your dry hair to make it look shinier, softer, and less oily.</td>
<td>[121,135]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metal oxides</td>
<td>Control hair grease.</td>
<td>[136-137]</td>
</tr>
</tbody>
</table>
Fullerene | Stop the free radicals and oxidative stress that lead to the death of hair follicles to encourage the creation of new hair follicles within the dermis of human skin, and aging | [138-140]

Carbon nanotubes | Nanoparticles' high surface area to volume ratio increases their affinity for and contact with hair fibres, leading to a long-lasting effect. | [141-142]

7. Toxicity of nanoparticles

The theme of the toxicological effects of "cosmeceuticals" made with a nanoformulation on the skin barrier. This implies that each nanoformulation must be carefully considered. NPs' permeability through the live tissues, is known to have a substantial impact on dermatological safety. Insoluble nanoparticles are supposed to be less harmful than soluble nanomaterials since they have a lower diffusion coefficient. Because the latter are typically made up of substances that are widely used in cosmetics (such as lipids and surfactants), their use has always raised more questions. Nanoparticle toxicity is highly dependent on a range of parameters, including surface characteristics. Smaller the size of particle more will be the surface area and thus shows more toxicity [143]. Toxicity is also influenced by the chemical composition of nanoparticles that are absorbed through the skin [144]. The level of exposure and the pathway through which nanoparticles enter the body determine the health risk they pose to people. Ingesting, inhaling, and dermal these are some of the potential ways that humans could be exposed to nanoparticles (Figure 13) [145].

7.1 Ingestion

The purposeful or unintentional transfer of nanomaterials from the hands to the mouth can result in the ingestion of such materials. After ingestion, the majority of nanoparticles quickly leave the body; however, some of the research we looked at suggested that a tiny proportion of nanoparticles might be absorbed and then reach into organs. Nanoparticles may be present in lipsticks, lip balms, lip glosses, and other cosmeceuticals and enter the body when used on the lips or mouth [146]. Certain nanomaterials can permeate the skin's layers within 24 hours of exposure. Mice subjected to 20 nm and 120 nm zinc oxide nanoparticles at different doses all exhibited problems in their spleen, hearts, livers, bones, and pancreas [147]. A range of widely marketed cosmeceuticals also contain copper nanoparticles. Mice treated with copper nanoparticles showed toxicological effects and severe internal organ damage [114]. Silver nanoparticles are utilized in several cosmeceuticals, including soaps, face creams, and toothpaste, as well as in wound dressing and antibacterial compositions. Silver nanoparticles are used in cosmetic industry due to
its antimicrobial effects. But the same silver concentration which is fatal for bacteria can also be harmful for keratinocytes and fibroblasts [148].

![Toxicity of Routes](image)

**Figure 13** Picture representation of toxicity route [145]

### 7.2 Inhalation

The National Institute of Occupational Health and Safety claims that inhalation is the most frequent way by which people are exposed to airborne nanoparticles. Workers might breathe in nanoparticles, for instance. Customers who use products containing nanoparticles, such as spray versions of sunscreens containing nanoscale titanium dioxide, may inhale them if the proper safety measures are not implemented during utilization. According to the National Institutes of Health authorities, the majority of inhaled particles migrate to the lungs. However, research on laboratory animals refer that some of the nanoparticles may go to the brain through the nasal passage and can also enter the blood, neurological system, and other organs.

According to carbon nanotube tests, long-term exposure can cause interstitial inflammation and also results in epithelioid granulomatous lesions. Some carbon-based fullerenes may cause cell oxidation or pose a risk to health if inhaled [149]. The pulmonary administration of TiO$_2$ ultrafine particles caused higher lung damage than TiO$_2$ fine particles. Gold nanoparticles with sizes of 2, 40, and 100 nm were found in the liver and macrophages after intratracheal exposure. There is evidence that even low doses of exposure to TiO$_2$ can destroy DNA, but TiO$_2$ with a particle size of 500 nm only slightly damages DNA strands. [150]

### 7.3 Dermal route

Three different pathways, including intracellular, transcellular, and trans follicular, are used to penetrate cosmeceuticals in the skin. The consequences of cutaneous exposure to particles smaller than 10 nm can be devastating. For particles larger than 30 nm, there is a chance that skin barrier modifications including cuts, wounds, and dermatitis diseases will affect nanoparticle penetration [151]. Currently, fullerenes are utilized in cosmeceuticals like moisturizers and face creams, although it is unclear how harmful they are. According to a report fullerene-containing face creams have been shown to harm fish brain tissue and have harmful effects on human liver cells [152]. According to several research, peptides
based on fullerene can penetrate into the skin and can easily cross the dermal layer when subjected to mechanical stress. Some studies have demonstrated that nanoparticles such as titania, quantum dots with surface coatings, and single- or multi-wall carbon nanotubes are capable of killing epidermal keratinocytes and fibroblasts by altering gene or protein expression [153]. Nanoparticles such as TiO₂ and ZnO present in sunscreens and their effects on human health safety, and the environment are currently not widely debated. Reactive oxygen species (ROS), including free radicals, are used more frequently due to their smaller size, higher surface area, and more reactive chemical makeup. The main mechanism for nanoparticle toxicity is the generation of free radicals and reactive oxygen species. TiO₂ and ZnO both produce reactive oxygen species as well as free radicals when exposed to ultraviolet (UV) light, which can cause oxidative stress and seriously disrupt cell membranes, proteins, RNA, and lipids [154]. A research revealed that when TiO₂ nanoparticle were delivered subcutaneously to pregnant mice, the nanoparticles were transferred to the offspring and caused lower sperm production in male offspring as well as brain damage. Cobalt-chromium nanoparticles can penetrate the skin's protective layer and harm human fibroblasts [155].

8. Safety assessment of nanomaterials in the cosmetic industry

Nanotechnology-based cosmetic firms face an uncertain future in terms of customer response and the regulatory landscape. Cosmetic nanomaterials may serve a variety of purposes (Nano-preservatives, UVA and UVB filters in sunscreen, etc.). Consumers may also be at risk from the distinctive properties of any specific nanomaterial that could give the cosmetic product the desired function or functionality. In light of this, a general assessment of the safety of all nanomaterials is required, including tests addressing the nano-characteristics. And Nanomaterial synthesis may result in exposure by eating, skin contact, and inhalation. The manufacturing of nanoparticles includes skin contact, which results in unintentional exposure. Inhalation exposure may be caused by the direct release of nanoscale airborne reactants or products at work. Nevertheless, airborne nanoparticles may inevitably be in all manufacturing lines as a result of product recovery, extra processing, and cleaning.

Intentional cutaneous exposure to nanoparticles can occur through skin contact with cosmetics and direct application. In the form of sunscreen, TiO₂ and ZnO are in touch with the skin. Dermal exposure very certainly leads to swallowing exposure due to hand-to-mouth contact, and exposure to ingesting brought on by hand-to-mouth contact [156]. Because these particles are tiny and have strong hypersensitivity, they could become potentially fatal elements in causing unfavorable cellular toxicity and damaging effects. Nanomaterials with known harmful effects can enter living organisms through the mouth or nose and then travel to various organs and tissues throughout the body [157]. Based on several types of nanoparticles used in cosmetics, table 7 illustrates the effects of nanomaterials on people and figure 14 represents the safety assessments in cosmetics.
Figure 14 Outline for the NMs safety Assessment in cosmetics[158]

Table 7 Implication of nanomaterials in cosmetics to human

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Nanomaterials in cosmetics</th>
<th>The implication of NMs on Humans</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Metallic Nanomaterials</td>
<td>Tumors and inflammatory reactions membrane deterioration and DNA damage</td>
<td>[159-161]</td>
</tr>
<tr>
<td>2</td>
<td>Carbon Nanomaterials</td>
<td>Potential for cancer if breathed fibrotic lesions that are inflammatory and present in the lungs and may cause granulomas inflammation and skin sensitivity</td>
<td>[12,162]</td>
</tr>
<tr>
<td>3</td>
<td>Polymer-based Nanomaterials</td>
<td>Inflammation of the airways momentarily, Zeolites suspended in an alkaline solution may cause skin or mucosal irritation, impede the immune system's reaction to common allergens</td>
<td>[163]</td>
</tr>
<tr>
<td>4</td>
<td>Lipid-based Nanomaterials</td>
<td>Nontoxic, biodegradable, and biocompatible; less harmful</td>
<td>[164]</td>
</tr>
</tbody>
</table>
Sprays and aerosols that could contain NMs should be subject to a more thorough safety assessment because inhalation exposure is a possibility.

An incomplete list of factors that are contained in the Scientific Committee on Consumer Safety, (SCCS/1602/18) is required in a case involving exposure to these nanoparticles. The concentration of nanomaterials is expressed in terms of particle number concentration and the surface area should be used to express the concentration in addition to the weight-based concentration of the NM. The European Parliament gave its approval to the revised European Union Cosmetics Directive, which included a reference to "nanomaterials" in EU law. According to European Parliament, the new law establishes a process for evaluating the safety of all nanomaterial-containing products, which could result in the banning of a chemical if they are causing a risk to human health. [165] The following are some of the most significant quotes from the act [166]

According to the ruling, a nanomaterial is "a purposefully created insoluble or bio-persistent material with one or more exterior dimensions, or an interior structure, on the scale from 1 to 100 nm."

- The accountable person makes sure for safety compliances, Good Manufacturing Practices, safety assessment, file containing product information, annexure list for restricted substances, regular sampling, analysis, labeling, animal testing, notification, restrictions for substances listed in annexes, carcinogenic, mutagenic and toxic substances for reproduction and public information.
- Communication of SUE, and information on substances are all followed.
- The responsible party must provide the Commission with the following information before releasing the cosmetic product for sale.
  A) Substances in nanomaterial form present in product.
  Their identifying information, which includes the chemical name and further details.
  B) The exposure circumstances that were conceivably foreseen.
- The SCCS opinion on the safety of the nanomaterial must be promptly requested by the Commission if it has any reservations about its suitability.
- All components included in the form of nanomaterials shall be explicitly mentioned in the ingredients list for the relevant categories of cosmetic goods and the reasonably foreseeable exposure conditions. The word "nano" in brackets must come after the names of these substances.
- Any potential effects on the toxicological profile caused by
  A) Particle sizes, including nanomaterials;
  B) Impurities of the chemicals and raw materials employed; and
  C) Substance Interactions shall be given particular care.
9. **Advantages and disadvantages of nanocosmetics**

There is a debate that NPs have a significant impact on human health. Both positive and negative impacts are there (Fig.15) [167].

![Advantages and disadvantages of nano systems in cosmetic formulations](image)

**Fig.15 Advantages and disadvantages of nano systems in cosmetic formulations**

**Conclusions**

The cosmetics industry has seen an upsurge in interest in nanotechnology. Cosmetic goods now contain a variety of nanoparticle and nanomaterial types. Thanks to the use of nanotechnology, active compounds can reach deeper layers of the skin and can be successfully supplied to the desired place. However, rather than becoming complacent just in the financially lucrative aesthetic arena, there is a need for more research into the health ramifications of these skin applications. Although the amount of information on the toxicity of nanoparticles is still growing, it is crucial. Advancements in the nano-system preparation techniques, improvement of evaluations/tests for quality check, and efficacy are some areas of advancement as businesses strive to introduce products that are not tested on animals and to create "cruelty-free" products that are completely recyclable and environmentally friendly. Scientists have developed new methods of distribution and technological advancements that are being used in the production of cosmeceuticals. Due to the rise in nano cosmeceuticals traditional delivery methods are being replaced by unique ones.
Liposomes, niosomes, nanostructured lipid carriers, solid lipid nanoparticles, gold nanoparticles, nanoemulsions, and nanosomes are novel nanocarriers which are now used in a variety of cosmeceuticals. These innovative drug delivery methods offer great potential to achieve several goals, including site attentiveness, improved stability, biocompatibility, extended action, and increased drug-loading capacity. Because there aren't enough strong arguments to support effectiveness claims, businesses must offer them. There are significant disagreements over the toxicity and safety of nanomaterials, and numerous studies are being conducted to identify the potential effect, toxins, and health risks. Careful research is needed on the safety potential of nanomaterials. Nanoproducts ought to be developed in such a way as to improve both their worth and the health of their consumers. Cosmetics are exempt from the need for clinical trials; thus, producers take advantage of this exemption and forego expensive and time-consuming trials.

References


[40] Decorte, https://www.decortecosmetics.com/skincare/liposome


[89] M.F.R.G. Dias, Educational Website for Cosmetologists.

[90] O. Sonneville-Aubrun, M. Yukuyama, and A. Pizzino, Application of nanoemulsions in cosmetics. Nanoemulsions: Formulation, Applications and


[137] S. Dickhof, J. Franklin, P. Busch, C. Kropf, and D. Fischer, Cosmetic composition, for preventing greasy appearance on hair, contains nanoparticles of oxide, oxide-


