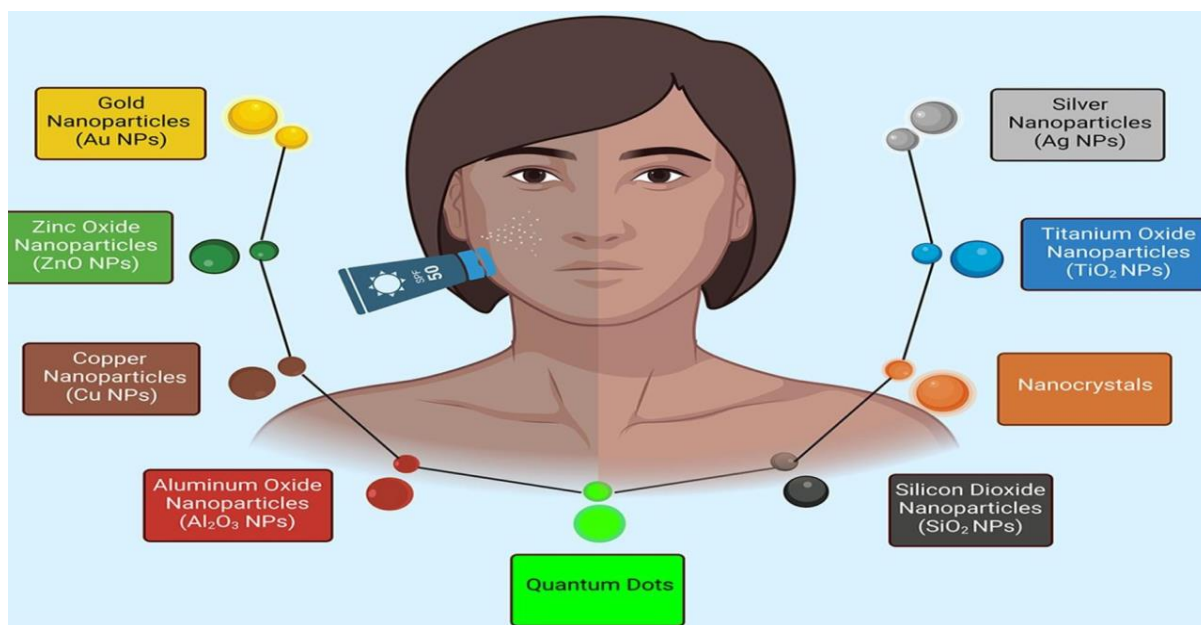


### Nanomaterials a boon or bane? to the cosmetic industry

Nanomaterials represent a significant category of materials known for their unique physicochemical properties, which have attracted considerable attention across various industries, including cosmetics. The cosmetics industry was one of the first to adopt nanotechnology-based materials, with nano-based ingredients being utilized for over 30 years. In the European Union, nanomaterials in cosmetics are officially defined as “insoluble or bio-persistent and intentionally manufactured materials with one or more external dimensions, or an internal structure, on the scale from 1 to 100 nm.”

Cosmetics formulated with nanomaterials offer several unique advantages over traditional, micro-scale formulations. The high surface area of nanomaterials enhances the efficient transport of ingredients through the skin, aiming for longer-lasting effects and increased stability. The primary objectives of using nanomaterials in cosmetics include efficient skin penetration for improved ingredient delivery, the introduction of new color elements in products like lipsticks and nail polishes, transparency in sunscreens, and long-lasting effects in makeup.



Cosmeceuticals are products that combine therapeutic active ingredients with traditional cosmetics, providing measurable restorative effects on the skin and hair. These products are used to treat various conditions such as damaged hair, wrinkles, photoaging, skin dryness, light

spots, and hyperpigmentation. Serving as a bridge between pharmaceuticals and beauty products, cosmeceuticals offer significant improvements in appearance.

Currently, cosmeceuticals represent one of the fastest-growing segments of the personal care industry, with the market expanding rapidly. This growth drives an increasing demand for research, exploration, and application of nanocosmeceuticals, which leverage nanotechnology to enhance the efficacy and benefits of these innovative products

Nanomaterials are increasingly being used in cosmetics for various benefits such as enhanced UV protection, improved delivery of active ingredients, and superior texture and appearance. Here are some key uses and benefits:

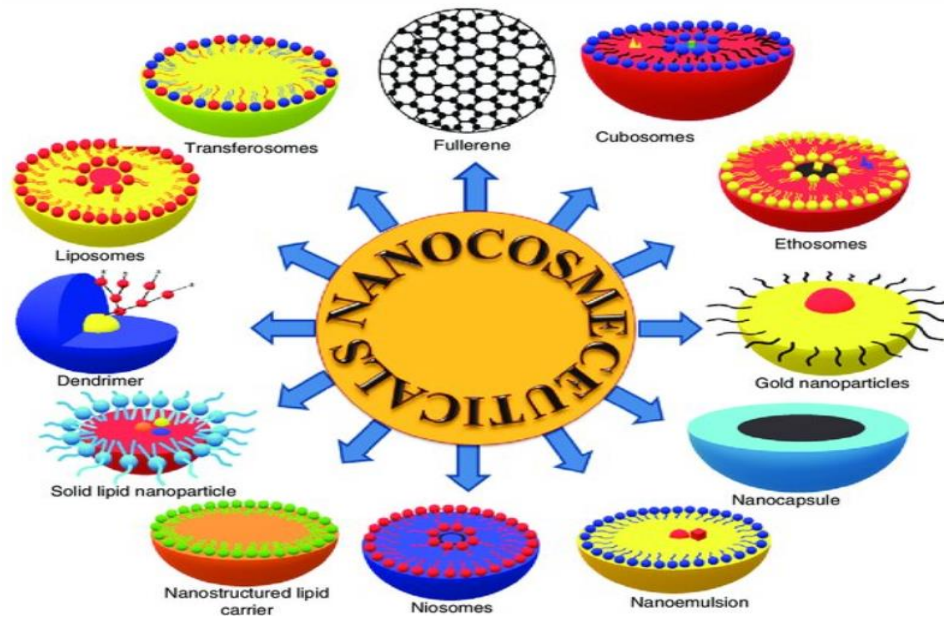
### 1. Enhanced UV Protection:

- **Titanium Dioxide (TiO<sub>2</sub>) and Zinc Oxide (ZnO) Nanoparticles:** These nanoparticles are commonly used in sunscreens due to their ability to provide better UV protection while being less visible on the skin compared to their larger particle counterparts.



### 2. Improved Delivery Systems:

- **Liposomes and Niosomes:** These nanocarriers encapsulate active ingredients, enhancing their stability and penetration into the skin. They can deliver vitamins, antioxidants, and other beneficial compounds more effectively.
- **Nanocapsules and Nanoemulsions:** These systems improve the solubility and bioavailability of poorly soluble ingredients, ensuring better absorption and efficacy.



### 3. Anti-aging and Skin Care:

- **Gold and Silver Nanoparticles:** These nanoparticles have antioxidant and anti-inflammatory properties. They can promote collagen production and reduce signs of aging such as wrinkles and fine lines.
- **Hyaluronic Acid Nanoparticles:** These are used to deliver moisture more effectively into the deeper layers of the skin, enhancing hydration and plumpness.



### 4. Improved Aesthetic Qualities:

- **Silica Nanoparticles:** Used in foundations and powders, these nanoparticles provide a smooth texture and enhance the dispersion of pigments, leading to a more even and natural finish.



### 5. Antibacterial Properties:

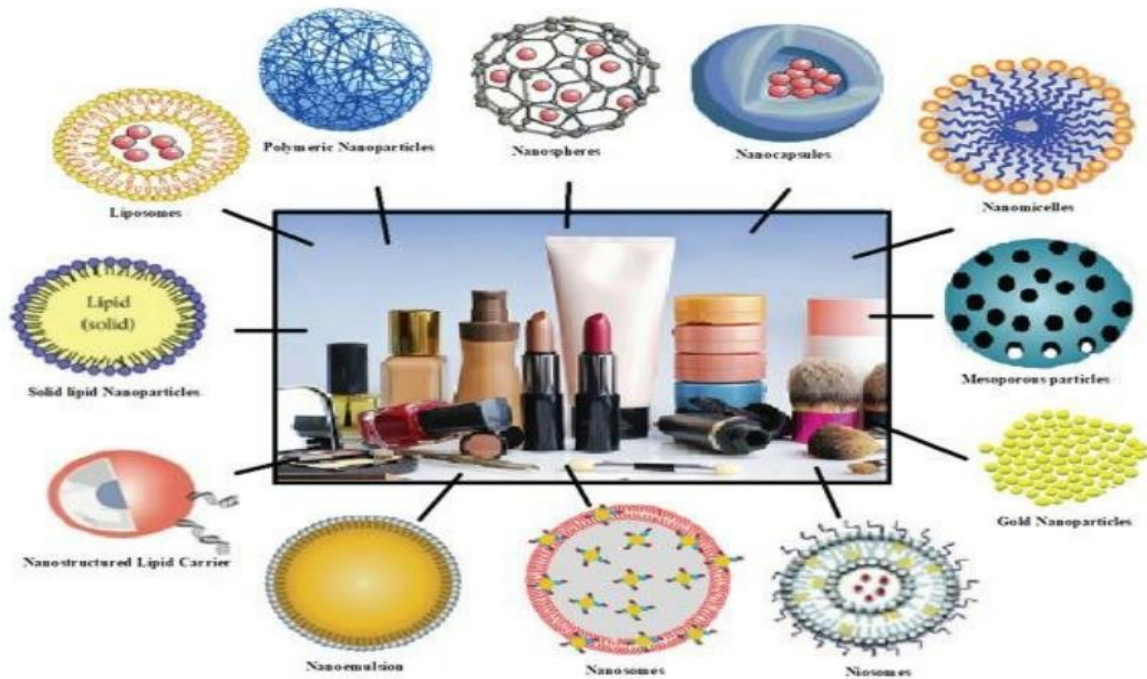
- **Silver Nanoparticles:** These are incorporated into products for their antimicrobial properties, helping to reduce acne and other skin infections.

### 6. Hair Care:

- **Nanomaterials in Shampoos and Conditioners:** Nanoparticles can help deliver active ingredients like vitamins and oils more effectively to the hair and scalp, promoting healthier hair.



Nanomaterial formulations in cosmetics come in various types, each designed to enhance the performance and efficacy of cosmetic products. Here are some key types of nanomaterial formulations used in the industry:



### 1. Nanoparticles:

- **Titanium Dioxide (TiO<sub>2</sub>) and Zinc Oxide (ZnO):** Commonly used in sunscreens for their excellent UV-blocking capabilities while remaining invisible on the skin.
- **Gold and Silver Nanoparticles:** Used in anti-aging and skincare products for their antioxidant and anti-inflammatory properties.

### 2. Liposomes:

- Spherical vesicles made from lipid bilayers that encapsulate active ingredients, enhancing their stability and penetration into the skin. Commonly used for delivering vitamins, peptides, and other beneficial compounds.

### 3. Nanoemulsions:

- Colloidal dispersions of two immiscible liquids (e.g., oil and water) stabilized by surfactants. Nanoemulsions improve the delivery and bioavailability of active ingredients, providing better hydration and skin penetration.

### 4. Nanocapsules:

- Small capsules with a core-shell structure, where the active ingredient is encapsulated within a polymer or lipid shell. These enhance the stability and controlled release of the encapsulated ingredients.

#### **5. Solid Lipid Nanoparticles (SLNs) and Nanostructured Lipid Carriers (NLCs):**

- Lipid-based nanocarriers that enhance the delivery and stability of active ingredients. SLNs are composed of solid lipids, while NLCs are made of a blend of solid and liquid lipids, offering better loading capacity and controlled release.

#### **6. Niosomes:**

- Non-ionic surfactant-based vesicles similar to liposomes. Niosomes are used to encapsulate and deliver active ingredients, improving their stability and bioavailability.

#### **7. Dendrimers:**

- Highly branched, tree-like polymers that can carry multiple active ingredients within their structure. Dendrimers enhance the solubility and delivery of poorly soluble ingredients.

#### **8. Fullerenes:**

- Carbon-based nanomaterials with a spherical structure, known for their antioxidant properties. Fullerenes are used in anti-aging and skincare products to combat oxidative stress and protect the skin.

#### **9. Nanofibers:**

- Extremely thin fibers used in wound healing and skin regeneration products. Nanofibers provide a scaffold for cell growth and can deliver active ingredients to the skin.

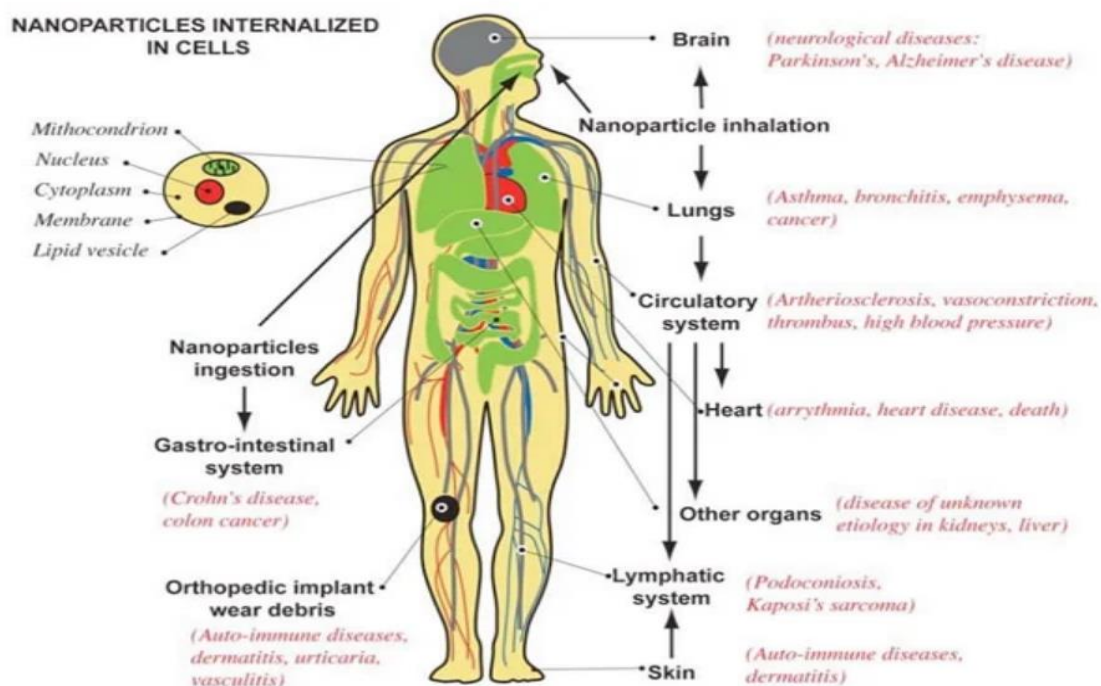
#### **10. Quantum Dots:**

- Semiconductor nanocrystals used in cosmetic formulations for their unique optical properties, providing luminescent effects and color enhancement in makeup products.

### **Applications and Benefits**

These nanomaterial formulations are employed across various cosmetic products, including sunscreens, anti-aging creams, moisturizers, makeup, and hair care products. They offer several benefits, such as improved stability, enhanced delivery of active ingredients, better skin penetration, and superior aesthetic qualities.

## Safety and Regulation



While nanomaterials offer many benefits, their safety is still a topic of ongoing research and regulatory scrutiny. Some potential concerns include:

- **Penetration and Toxicity:** The small size of nanoparticles allows them to penetrate deeper into the skin, potentially leading to unknown biological effects.
- **Environmental Impact:** Nanoparticles can enter the environment through wastewater and may pose risks to aquatic life.

Regulatory bodies like the FDA in the United States and the European Commission in the EU are working to establish guidelines and safety assessments for the use of nanomaterials in cosmetics to ensure consumer safety.

### **Recent update: The EU bans the use of several nanomaterials in cosmetics**

In March 2024, the European Commission published a new regulation, the [Commission Regulation \(EU\) 2024/858](#), restricting and/or prohibiting the use of certain nanomaterials in cosmetic products. This regulation takes into account the SCCS (Scientific Committee on Consumer Safety) opinions of the past years, which conclude that due to the lack of sufficient data to assess the safety and the potential mutagenic/genotoxic and immunotoxic/nephrotoxic effects of some of the nanomaterials, they can pose a health risk to the consumer when used in cosmetic products.

Considering this, the European Commission has decided to amend Regulation (EC) No 1223/2009, adding the following nanomaterials to Annex II (From 1 February 2025 cosmetic products containing these substances shall not be placed on the Union market. From 1

November 2025 cosmetic products containing these substances shall not be made available on the Union market):

- Styrene/Acrylates copolymer (nano), CAS 9010-92-8
- Sodium Styrene/Acrylates copolymer (nano), CAS 9010-92-8
- Copper (nano), CAS 7440-50-8
- Colloidal Copper (nano), CAS 7440-50-8
- Colloidal silver (nano), CAS 7440-22-4
- Gold (nano), CAS 7440-57-5
- Colloidal Gold (nano), CAS 7440-57-5
- Gold Thioethylamino Hyaluronic Acid (nano), CAS 1360157-34-1
- Acetyl heptapeptide-9 Colloidal gold (nano)
- Platinum (nano), CAS 7440-06-4
- Colloidal Platinum (nano), CAS 7440-06-4
- Acetyl tetrapeptide-17 Colloidal Platinum (nano)

### **Conclusion**

Nanotechnology is currently seen as a groundbreaking field with promising applications in cosmetics, cosmeceuticals, dermatology, and biomedical fields. The introduction of advanced drug delivery systems has increased the popularity and market share of these products. Nowadays, cosmetics are an essential part of daily routines, and the incorporation of nanotechnology has further boosted their acceptance globally. However, the potential toxicity of nanomaterials due to their penetrability is a significant concern, often overlooked, leading to adverse health effects. Novel nanocarriers such as liposomes, ethosomes, cubosomes, NLC, SLNs, nanoemulsions, and niosomes are used to create cosmetics and cosmeceuticals with improved outcomes. These nanosystems deliver formulations across the skin via various mechanisms, offering benefits like sun protection, moisturization, and wrinkle reduction. Despite their growing market value, the safety and toxicity of these nanomaterial products in humans remain hotly debated, necessitating more thorough investigations.

Cosmetic legislation should mandate a comprehensive list of references and ingredients that could have unintended environmental effects to ensure user safety. Long-term toxicity and carcinogenicity studies of cosmetics, including those with nanomaterials, should be conducted before commercialization. Nanocosmeceuticals should be developed to enhance consumer health, and rigorous clinical trials akin to those for drugs should be performed to ensure formulation safety. Additionally, stringent regulations on the manufacturing, storage, import, and marketing of cosmeceuticals and their nanoparticles are necessary.



Global collaboration among researchers and regulatory agencies is essential to establish standard rules and regulations for nanotechnology use in cosmetics, addressing existing data gaps. Non-governmental organizations and government bodies should work together to create and disseminate educational materials for consumers. These efforts should include written and video content distributed through various media channels and seminars to educate on the wise use of nanocosmetics and nanocosmeceuticals. Finally, harmonizing international regulations is crucial to develop a robust regulatory framework that ensures safety, efficacy, and proper marketing, ultimately benefiting the cosmetic industry and protecting consumers from potential hazards. Increased consumer awareness can also help improve the situation by enabling informed product choices.