# ADVENT OF NANOTECHNOLOGY IN THE FIELD OF SKINCARE COSMECEUTICALS

Dr. Iqra Haider[1], Muhammad Hasan Raza Azmi[2], Malaika Farhan[3,]

Fareeha Waseem[4], Syed Ali Hasnain[5], Saifullah Sheikh[5]

[1]Faculty Of Pharmacy
Hamdard University
Iqra.haider@hamdard.edu.pk

[2]Faculty Of Pharmacy
Hamdard University
Hasanazmi0@gmail.com

[3]Faculty Of Pharmacy
Hamdard University
Malaikafarhan1@gmail.com

[4]Faculty Of Pharmacy
Hamdard University
Fareehawasimsheikh278@gmail.com

[5]Faculty Of Pharmacy
Hamdard University
Hasnainhoney450@gmail.com

[6]Faculty Of Pharmacy
Hamdard University
Ssaifullah0301@gmail.com

# Advent of Nanotechnology in the Field of Skincare Cosmeceuticals


## Abstract

Use of cosmeceutical is diverse for curing the conditions like photo aging, wrinkles, hyperpigmentation, sunburn and hair damage. For thegrowing population and increased demand, cosmeceutical industries are the rapid growing segment on the graph. In the area of cosmetics, nanoparticle is the topic of concern as the absorption on faster rates and efficient damage repair can be achieved significantly through the use of the particles measured at the nanometer scale. In cosmeceuticals, nanoparticles can be used in the form of liposomes, nanocapsule, nanocrystals, dendrimers, cubosomes, niosomes, nanogold and nanosilver. Nanoparticles can be synthesized physically, chemically and biologically unlocking their diverse use into the formulations accordingly. This fast-developing technology has been widely exploited for diagnostic and therapeutic purposes. Today, cosmetic formulations incorporating nanotechnology are a relatively new yet very promising and highly researched area. The application of nanotechnology in cosmetics has been shown to overcome the drawbacks associated with traditional cosmetics and also to add more useful features to a formulation.The use of nanotechnology in the arena of cosmeceuticals is appreciated for the enhanced penetration of the drug, site specific drug action, the higher stability of vulnerable compounds, and sustained release action of a drug. This article seeks to provide an overview of nanocosmetics and nanocosmeceuticals and their applications in cosmetic industries, which may help consumers and regulators to gain awareness about the benefits as well as the toxicity related to the continuous and long-term uses of these products, thus encouraging their judicious use.Apart from the benefits of the nanotechnology in the field of cosmeceuticals, questions have been raised for the persistent use of the product having any Nano toxicological effects and health hazards. This review will disclose the science behind the formation of nanoparticles and their use in the fieldof cosmeceuticals.



**Keywords:** cosmeceuticals, nanotechnology, nanotoxicity, deliverysystem, sunprotectants, anti-aging.

## INTRODUCTION

Many of the cosmeceutical based industries manufacture their products through the use of the particles measured at the nanometer scale i.e. nanoparticles. Cosmeceutical industry utilizes nanotechnology as the absorption is on faster rates and efficient damage repair can be achieved significantly.[1,2,3] Cosmeceutical industries are the rapid growing segment on the graph. Back in 2014 it was forecasted that the cosmeceutical market will reach $31.84 billion by 2016, $42.4 billion by 2018 and indicated to reach 80.36 billion by 2023 with an annual growth rate of 9.38% from 2016 to 2022.[3,4,5,6] · Cosmeceuticals are considered as niche between pharmaceuticals and cosmetics where the products are enriched with measurable therapeutic efficacies of bioactive components and the formulations are diversified from skin to body to hair in order to use for various treatment such as skin aging, hair damage, skin dryness, dark spots, pigmentation etc. Nanotechnology is known as the most forthcoming technology of twenty-first century and scrutinized as an inventive approach in cosmetic industry. It has been defined as an innovative science that including the design, production, characterizations, and application of science, where the particles can be manipulated in the ranges between 10 and 1,000 nm (Logothethetidis, 2012; Kaul et al., 2018). Nano- cosmeceuticals is elucidated as a cosmetic formulation incorporated with nanotechnology as delivery system to promote an enhancement performance of bioactive components. [1] Other nanosized forms are applied in sunscreens, anti-ageing products, razors and curling tongs [2]. For the purpose of this paper, fundamentals of cosmetics and nanomaterials are covered, the peculiar properties of nanoparticles necessitating their use in cosmetics are highlighted, expounding on seemingly familiar terms for clarity. The write up will also take a look at the common current innovative nanomaterials employed in cosmetic manufacture, their unique properties, highlighting the hidden challenges associated with nanocosmeceuticals and the support necessary from regulatory authorities is not overlooked.The word “cosmeceutical” has no definition. As per the FederalFood Drug and Cosmetic Act (FD&C Act), there is no such word as “cosmeceutical”. This word is only usedfor industrial purposes to refer to cosmetic products with therapeutic actions. they possess limitations related to stability, scalability, toxicity, cost, etc. Moreover, the safety and toxicity profiles of nanomaterials are still debatable. The small size, increased surface area, and positive surface charge of nanoparticles improve their ability to interact with the microenvironment biologically. On the other hand, they have dose-dependent toxicity through different routes of administration. It is well known that the bioavailability of an active ingredient is better influenced by the dosage rather than the physicochemical properties of the active moiety.Cosmeceuticals are contemplated as the fastest growing fragment of personal care industry and the market for personal care is increasing enormously

There are a number of advantages of nanocosmeceuticals. Namely, they provide the controlled release of active substances by controlling the drug release from carriers by several factors including physical or chemical interaction among the components, composition of drug, polymer and additives, ratio, and preparation method. Applying nanotechnology in the development of cosmeceuticals offers numerous advantages like targeting of the active therapeutic component to the desired site greater skin retention improvement in the stability of cosmetic ingredients; greater aesthetic appearance and sustained release of active drug for long-lasting effect [6, 7]. Some of the nanotechnology-based novel carriers of cosmetics include nanoemulsion, nanocapsule, liposome, niosome, nanocrystal, solid lipid nanoparticle, carbon nanotube, fullerene and dendrimers. In the human body, there are numerous nanostructures without whichthe normal functioning of the body is impossible, i.e., enzymes, proteins, antibodies, or DNA. Human bone, which is a multifaceted composite of hierarchical inorganic nanohydroxyapatite and organic. Nanoparticles are ubiquitous in cosmetic products as antioxidants and anti-reflectants. Examples include TiO2-NPs addedto creams as a white pigment or Ag-NPs as a component of shampoos and toothpaste.

Obtaining a therapeutic effect in the dermal or transdermal administration of drugs or cosmetic preparations chiefly depends on passing through the skin barrier.By the 21th century, the cosmetics are being enormously used and with the development in technology, innovative cosmetic formulations are being developed by the incorporation of the latest technologies.

Cosmeceuticals are the cosmetic products which incorporate biologically active ingredient having therapeutic benefits on the surface applied. These are utilized as cosmetics as they claim to enhanceappearance.

By having very small size of the particles, the surface area is increased which allows the active transport of the active ingredients into the skin. Occlusion provides the enhancement in the penetration and skin hydration is increased. Cosmeceuticals have high entrapment efficiency and good sensorial properties and are more stable than the conventional cosmetics. Most of the nanoparticles are suitable for both lipophilic and hydrophilic drug delivery. Nanocosmeceuticals may be harmful to environment as well. No clinical trialsare required for the approval of nanocosmeceuticals, thus raising a concern of toxicity after use.

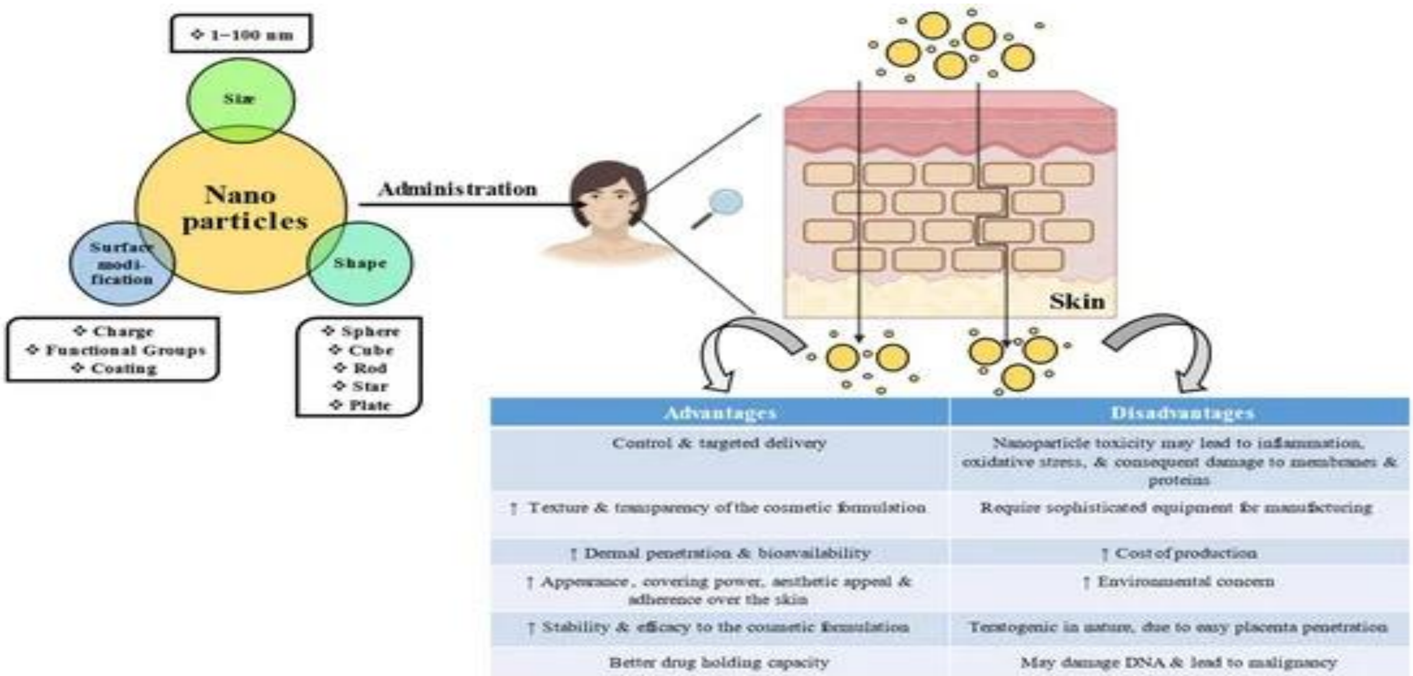


*Figure 1 advantages and disadvantages of nanotechnology*

## METHODOLOGY

The fields of research known as nanotechnology and nanodelivery systems are cutting-edge fields that focus on the design, characterisation, production, and use of materials, devices, and systems at the nanoscale (1-100 nm). The field of cosmetics and cosmeceuticals has conducted substantial research on nanotechnology, which is acknowledged as one of the changing technologies.

Presently, nanomaterials are attracting attention in this area, as they offer greater advantages over traditionally used cosmetic products. Further, the amalgamation of nanomaterials has greatly contributed to the global increase in the market share of pharmaceuticals and cosmetics. In the year 2019, the international market size of nanomaterials was estimated to be USD 8.5 billion and is expected to increase with up to a 13.1% compound annual growth rate from the years 2020 to 2027. Although the concept of nanomaterials (gold and silver nanoparticles) has been used in cosmetics for several years, the extensivity of applications has intensified in recent years. The number of people suffering from skin problems such as dermatitis, skin disorders such as eczema, psoriasis, hives and ichthyosis, sunburn, acne, dry skin and other skin diseases, along with Many other conditions are increasing.

| S.no. | Technique | Method for synthesis |
|---|---|---|
| 1 | Co-precipitation | Simultaneous nucleation, growth, coarsening, and/or agglomeration processes |
| 2 | Hydrothermal | Chemical reaction of compounds in sealed container with elevated temperature and pressure |
| 3 | Inert Gas Condensation | Metals are evaporated in vacuum chamber under high pressure filled with inert g Evaporated metal atom oncollision to gas molecule condense into particle by the transfer of energy |
| 4 | Sputtering | Ejection of atoms from material's surface through bombarding energetic particles and the subsequent deposition on substrate |
| 5 | Laser ablation | Removal of material from surface by irradiation with a laser beam |
| 6 | Ultrasound | Ultrasonic irradiation causes ultrasonic cavitation which provide good environment for chemical reaction like high temperature and hi pressure |

*Table 1 techniques used in nanotechnology*

## 1.1 Liposome

Liposomes are spherical self-enclosed vesicles with a basic structure of bilayer phospholipid. Their size can vary from 20nm to few hundred micrometer.[1,5] On the basis of their preparation methods, lipid vesicles can be unilamellar or multilamellar, having one or multiple bilayer shells.[4,7] They can bemanufactured by rupturing the biological membranes (sonication).[8] the penetration capability is greatly enhanced using liposomes also stability of the enclosed medicament is increased.[7]

**Nanoemulsion** Nanoemulsio is a thermodynamically stable dispersion system in which water phase and oil phase coexist with surfactant.[3] Thesize vary from 10nm-300nm.[4]Multiple emulsions arepreferred over single emulsion due to their wider applicationsand reduced costs.[1,4] Bioactive compounds like polyphenols, flavonoids are formulated as nanoemulsion due to comparative less toxicities.[1,4]

## 1.1 Niosome

Niosomes are the nano-lamellar structures made up of nonionic surfactants.their size ranges from 100nm-2µm [1,3-5,8,9] The core of niosome is of aqueous phase, covered with the nonionic surfactant in lamellarfashion.[1,3,5,8] They are efficient as their resident time is much greater also theyprevent the systemic absorption thus increasing the local therapeutic effect.[5] Theywere first discovered by L'Oréal in 1970, thenpatented and marketed in 1987 under the trade name of Lancôme.[3]

**Nanosphere** Nanospheres are the structures wherea drug molecule is dissolved or encapsulated in thepolymeric matrix.[3,8] They are used for the drug to penetrate todeep layers of skin. Due to thislevel of penetration, antiwrinckleand antiaging effects have beenachieved.[3]

### Novel nanoparticle based Dermal cosmeceuticals

**Nanocapsule** Nanocapsule is a vesicular system wherean inner liquid resides inthe polymeric covering.Their size ranges from10-1000 nm[1,9]. The French company L'Oréal for the first time in 1995used this nanocarrier to enhance their cosmetics.[1,2,5,7,9]

| S.no. | Trade name | Proposed use | Manufacturer | Nanotechnology used |
|---|---|---|---|---|
| 1 | Anti-Age Response Cream | Anti-wrinkle | Simply Man Match | Niosome |
| 2 | Anti-Wrinkle Sun Cream SPF 15 | Anti-wrinkle | Lancôme | Nanocapsule |
| 3 | Bepanthol-Protect Facial Cream Ultra | Antiaging/moisturizer | Bayer Health Care | Nanoemulsion |
| 4 | Capture Totale | Antiwrinkle/sunscreen | Dior | Liposome |
| 5 | Clear It! Complex Mist | Antiacne | Kara Vita | Nanosphere |
| 6 | Coni Hyaluronic Acid &Nanoemulsion IntensiveHydration Toner | Skin hydration | Coni Beauty | Nanoemulsion |
| 7 | Dermosome | Moisturizer | Microfluidics | Liposome |
| 8 | Eye Tender | Antiwrinkle | Kara Vita | Nanosphere |
| 9 | Niosome+ | Foundation cream | Lancôme | Niosome |
| 10 | Primordiale Optimum lip | Lip treatment | Lancôme | Nanocapsule |

*Table 2 Trade names of products and its uses*

## Cosmetics using nanomaterials

The cosmetic industry is interested in nanoparticles such as solid lipid nanoparticles, liposomes, nanoemulsions, nanocrystals, Nicells, polymeric nanocapsules, and nanoencapsulations that are utilized in medication delivery systems. Concern over the health and environmental implications of using nanotechnology in cosmetics has grown significantly as a result of its widespread use. The advent of nanotechnology in skin care has led to significant advances in the formulation and delivery of skin care products. Nanotechnology involves processing materials at the nanoscale, typically between 1 and 100 nanometers, to create new properties and improve product performance. In the skin care industry, nanotechnology has been used to enhance the effectiveness of various skin care products. Here are some of the impacts of nanotechnology on skin care:

1. Improved Delivery Systems: The creation of nanocarriers is one of nanotechnology's most important contributions to the skincare industry. These are small nanoparticles that can transport active substances like peptides, antioxidants, and vitamins deep within the skin. This improves the substances' absorption and efficiency.
2. Ingredient Stability: Nanotechnology can assist stabilize delicate or quickly biodegradable chemicals, limiting their degradation and eventual loss of effectiveness. This implies that skincare products can keep working effectively for longer periods of time.
3. Enhanced Penetration: Nanoparticles are small enough to more efficiently penetrate the stratum corneum, the skin's outermost layer. As a result, active chemicals can be delivered to the skin's deeper layers, where they can have a more significant influence on problems including wrinkles, discoloration, and dehydration.
4. Sunscreen Protection: Broad-spectrum UV protection is often provided by sunscreens using nanoparticles. For instance, zinc oxide and titanium dioxide nanoparticles can provide strong sun protection without giving the skin an obvious white tint.
5. Customized Solutions: Nanotechnology allows the customisation of skincare products depending on a person's skin type and particular concerns. Results that are more successful may result from this customisation.
6. Reduced Irritation: By assuring a gradual release of the active component over time,nanotechnology can assist lessen this irritation. Some active substances can be irritating to the skin.lts.
7. Examples of using nanotechnology in skincare include:
8. Nanoparticle Sunscreens: Titanium dioxide or zinc oxide nanoparticles are frequently found in sunscreen creams. These transparent nanoparticles on the skin offer efficient UVA and UVB light protection without discoloring the skin. Because of the lower particle size, sunscreen can be both more effective and aesthetically pleasing.
9. Nanoliposomes: Liposomes are minuscule vesicles made of lipid (fat) that can contain active substances. Nanoliposomes are liposomes of nanoscale size that can penetrate the skin more effectively. They help increase the absorption of vitamins, antioxidants, and peptides by delivering them deeply into the skin.
10. Nanogels: Hydrogel-based formulations with nanoscale particles are known as nanogels. They hydrate the skin by being included in serums and moisturizers. Because of the lighter weight and non-greasy texture provided by the lower particle size, they are suited for all skin types.
11. Nanopeptides: Peptides are frequently used in skincare products to fight wrinkles and promote the creation of collagen. Smaller peptide molecules that can penetrate the skin more efficiently and produce greater outcomes can be produced using nanotechnology.
12. Nanomasks: Some skincare products, including sheet masks, have nanofibers in them. These nanofibers closely follow the contours of the face, facilitating enhanced product absorption and skin hydration from masks
13. Nanotechnology in Anti-Aging Creams: Active chemicals like coenzyme Q10 or ceramides may be delivered to the deeper layers of the skin by use of nanotechnology in anti-aging creams. This can increase skin suppleness and lessen the visibility of wrinkles and fine lines.
14. Botanical extracts that have been nanoencapsulated can be more stable and effective. Examples of this include green tea and chamomile. These nanocapsules can transfer the extracts' therapeutic properties to the skin more effectively.

It's crucial to remember that careful regulation of the use of nanotechnology in skincare products is necessary to protect consumer safety. To protect consumer safety, regulatory organizations like the FDA in the United States and the European Commission have set standards and limitations on the use of nanoparticles in cosmetics. Moreover, individuals

## Products in the market

- The lipid globules in the earliest nanometric cosmetic constructions ranged in size from 10 to 100 nanometers. The first item wasreleased in 1991 by Shiseido in Japan, and Lancôme later accepted them as essentials.
- Since then, numerous brands—including Kérastase (Aqua-oléum), Guerlain (Sérum antiâge), Chanel (Solution Destressante Précision), La Prairie (Cure Intensive AuxExtraits de Caviar), etc.—have developed nanoformulations as well.
- Later, cream jars started to include nanovectors. The active substances like beta- carotene, vitamin E, and/or vitamin A are stored in these reservoirs, which take the form of sponges or tiny shells. These reservoirs are in charge of delivering these substances deep within the epidermis.
- This foundation contains titanium oxide nanoparticles that are rich in iron. When exposed to either natural or artificial light,the foundation maintains the same makeupeffect while the latter darkens reversibly in accordance with brightness. The result is referred to as photochromic.
- A lot of patents have been filed in relation to nano titanium dioxide.The company then created silica and zinc dioxide nanoparticles, which inhibit the enzymes responsible for skin dryness and redness. At the nano-order level, the company blended oxide powder and talc powder. An inorganic powder could prevent the enzymes that cause dry skin, according to research on this compound.
- Gold Future at Helena Rubinstein containscolloidal gold, which is gold that is smaller than 10 microns. The bioavailability of goldis increased by small gold particles, which also enable the epidermis to take use of gold'santi-free radical characteristics.
- Nanosomes, tiny capsule-like structures that deliver active chemicals into the outer layer of the skin and subsequently release them,were the first nanoproducts, released roughly 15 years ago. Vitamin is added to anti- wrinkle cream using a unique nanocapsuletechnique created in the company's European facility.
- A new sunscreen called ZO1 from an Australian business employs tiny zinc oxide particles. Johnson & Johnson and EstéeLauder are also creating nanotechnology- basedproducts.

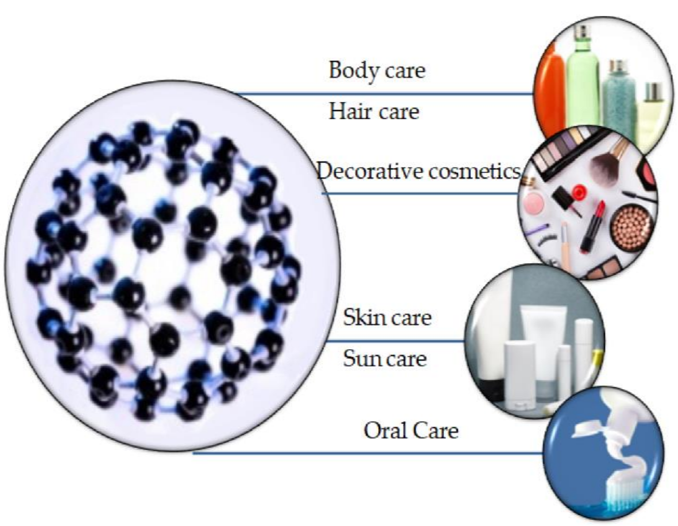


*Figure 2 types of cosmeceutical available in the market*

## Material and methods

Nanotechnology is the process of modifying materials at the nanoscale, which typically ranges from 1 to 100 nanometers, to produce new characteristics and uses. Nanotechnology uses a variety of materials, and the choice of material is determined by the particular application.

- Carbon Nanotubes (CNTs): Made of carbon atoms organized in a hexagonal lattice, carbon nanotubes are cylindrical objects. Their extraordinary strength, electrical conductivity, and thermal conductivity are well-known. CNTs are used in nanoelectronics, composite materials, and medication delivery systems.
- Nanoparticles: A variety of materials, including metals (such as gold, silver, and iron), semiconductors (such as silicon, quantum dots), and polymers, can be used to create nanoparticles. Because of their diminutive size and distinct characteristics, they are utilized in medicine delivery, imaging, and catalysis.
- Nanoparticle-based Polymers: Nanotechnology uses polymers with embedded nanoparticles to improve the characteristics of materials. To increase strength and barrier qualities, for instance, clay nanoparticles can be added to polymer matrices.
- Quantum dots are semiconductor nanoparticles with distinctive optical characteristics. Their tunable emission wavelengths are employed in displays, lighting, and biological imaging.
- Small crystals having dimensions on the nanoscale are known as nanocrystals. They serve as building blocks for more intricate nanostructures and are employed in optics and photonics.
- Fullerenes: The most well-known fullerene is C60 (buckminsterfullerene), which is a spherical carbon molecule. They are used in lubricants, superconductors, and medicine delivery.
- Nanofibers: A variety of materials, including polymers, carbon, and ceramics, can be used to create nanofibers. They can be used in textiles, tissue engineering, and filtration.

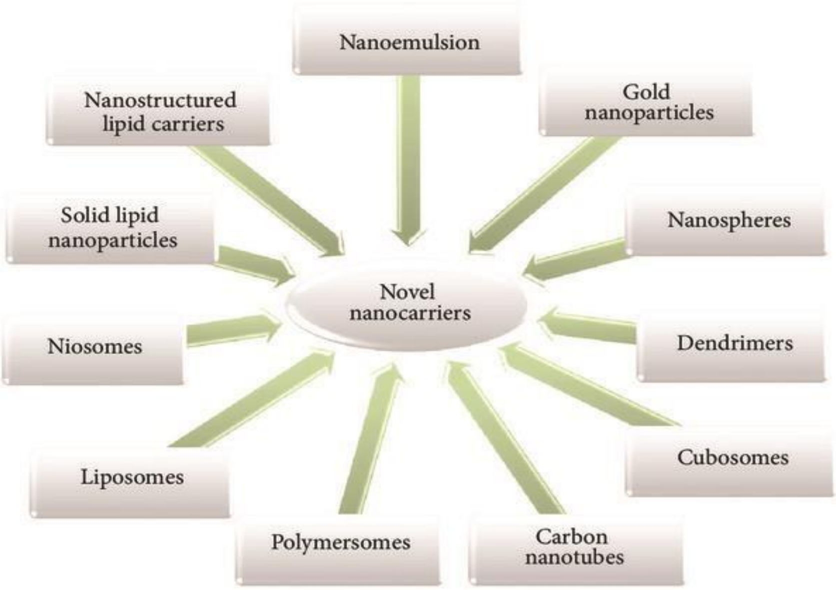


*Figure 3 Novel drugs of nano particles*

These are only a few types of materials that are utilized in nanotechnology. Innovations in areas like electronics, medicine, energy, and materials science are made possible by improvements in the synthesis and manipulation of nanomaterials, which are constantly expanding the range of materials that are suitable for use in nanotechnology applications.

|  | Technique | Technique | Advantages | Disdvantages |
|---|---|---|---|---|
| **1** | High-pressure homogenization | Olanzapine | Well-developed tech.,Scalable, Commercially demonstrated | Energy intensive process, damage to biomolecule. |
| **2** | Hot homogenization | Diazepam | Applicable to insoluble and lipophilic drugs, at high-temperature exposure time is short. | For hydrophilic drug there is low entrapment efficiency. |
| **3** | Cold homogenization | Vinorelbinbitartrate | Applicable for hydrophilic, thermo labile and thermo sensitive drugs | Exposure to heat can't be completely avoided |
| **4** | Microemulsion technique | Paclitaxel | Low mechanical energy input. | Sensitive to change, low Concentration of Nanoparticle |
| **5** | Ultrasonication | Insulin | Effective at laboratory scale reduced shear stress | Energy intensive process, high metal contamination potential |

*Table 3 Advantages and disadvantages of various techniques.*

**Conclusion**

*Figure 4 Cosmeceutical product in the market*

With the increasing demand of the growing population, the cosmeceutical industries are gradually rising. This review has outlined the use of nanotechnology in the formulations for their absorption on fasterrates and efficient damage repair and in dermatology specially for its therapeutic, diagnostic and preventive effects. Nanotechnology is a key technology offering advancement in both research and business circle. Consumers, on observing any intolerant reaction of nanocosmetic products they use, should promptly make a report to appropriate authorities. All thus have roles to play. From all indications, nanoparticles-contained cosmetics will continue to be relevant but it is important that relevance does not override health safety.These novel delivery systems have remarkable potential in achieving various aspects like controlled and targeted drug delivery, site specificity, better stability, biocompatibility, prolonged action, and higher drug-loading capacity. Small size of micellar nanoparticles can be successfully prepared through nanoemulsion system which promotes higher penetration rate of active component onto skin layers.There is lack of convincing evidences for the claims of effectiveness, so industries are required to provide them.Clinical trials are not required for the approval of cosmeceuticals so the manufacturers enjoy the benefit and avoid holding clinical trials and lengthy procedures.They should establish special programs, such as written and video materials, through multimedia or seminars with the aim to provide education for the wise use of cosmetics containing nanocosmetics and nanocosmeceuticals toxic or carcinogenicity studies of cosmetics, including nanocosmetics and nanocosmeceuticals (and their ingredients), should be conducted before the commercialization of these products. . Nanosystems carry and deliver these formulations across the skin by diverse mechanisms and impart several functions, such as sun protection, moisturization, wrinkle reduction, etc. Even though these nanomaterial products are gaining impressive market value, there is tremendous debate concerning their safety and toxicity in humans, demanding more careful investigations. Hence, the cosmetic legislation should provide a specific list of references as well as the ingredients that produce unintended environmental effects for all users of cosmetic products, such as consumers and professional users, thus ensuring the safety of the usage of cosmetic products. Long-term toxic or carcinogenicity studies of cosmetics, including nanocosmetics and nanocosmeceuticals (and their ingredients), should be conducted before the commercialization of these products. Nanocosmeceuticals should be manufactured in such a way that they add value to the health of consumers. Moreover, careful clinical trials of cosmeceuticals should be conducted, such as those performed for drugs, to assure the safety of the formulations in humans. Additionally, stringent regulations should be imposed on the manufacturing, storage, import, and marketing of cosmeceuticals and nanoparticles incorporated therein.

Nanocosmeceuticals should be manufactured in such a way thatthey add value to the health of consumers.Highly stable properties of nanoemulsion system posesses to offer no sedimentation, creaming, and sticky feeling after application of cosmetics.It also demonstrates that nanotechnology approach has huge potentials to be further implemented in wide range of cosmetic segments. The successful delivery system of nanoemulsion found in cosmetics, can be recommend to be implemented in another field such as food and pharmaceutical. Although available knowledge in toxicity of nanoparticles is still adding up, it is essential. Regulatory bodies for cosmetic products will need to do more than providing applicable guidelines and supervision but also be proactive in screening to determine approval or not for new and existing nanosized ingredients used in cosmetics

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