"NANOTECHNOLOGY IN COSMETICS: CURRENT TRENDS & FUTURE ADVANCEMENTS"

A PROJECT WORK (BP812PW) SUBMITTED TO

NIRMA UNIVERSITY

In partial fulfillment of the requirements for the degree of

Bachelor of Pharmacy

BY

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Semester VIII

UNDER THE GUIDANCE OF

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CERTIFICATE

This is to certify that Project Work (BP812PW) entitled "NANOTECHNOLOGY IN COSMETICS: CURRENT TRENDS & FUTURE ADVANCEMENTS" is the bonafide work carried out by JENISH KHAKHKHAR (19BPH052) , JIMIL PATEL (19BPH054), KEYABEN PATEL (19BPH060), KRISH PATEL (19BPH068), NETI JHALA (19BPH078) B.Pharm semester VIII under my guidance and supervision in the Institute of Pharmacy, Nirma University, Ahmedabad during the academic year 2022-2023. This work is up to my satisfaction.

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ABSTRACT

Development of novel formulations with improved functionality and performance made possible by nanotechnology has revolutionised the cosmetics industry. The use of nanotechnology in cosmetics is now trending and will continue to advance, as summarised in this review. Including liposomes, dendrimers, nanoparticles, and nanoemulsions, the first section gives an overview of the numerous nanomaterials utilised in cosmetics. The advantages of nanotechnology in cosmetics are discussed in the second section, including better skin penetration, improved stability and shelf life, and increased efficacy.The final section talks about the legal and safety concerns surrounding the use of nanotechnology in cosmetics.The overview is concluded with a discussion of the prospective applications of nanotechnology in the cosmetics industry, including customised cosmetics, smart cosmetics, and nanosensors for skin examination.Overall, the assessment emphasises the substantial influence nanotechnology has had on the cosmetics market as well as its potential for future expansion.

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1. NANOTECHNOLOGY

1.1 introduction

Nanotechnology is the practise of observing, measuring, manipulating, and producing objects at the nanoscale size. An SI (International system of units) unit of length 10-9 or one billionth of a metre is called a nanometer (nm)..

Nanotechnology is an innovative field of science that deals with the design, characterization, production, and use of materials, electronics, and systems. It does this by modifying shape and size at the nanoscale scale (1-100 nm).The newest and most cutting-edge technology currently available is the inclusion of nanotechnology in cosmetic composition. In order to provide benefits including improved UV protection, deeper skin penetration, long-lasting effects, better colour, higher finish quality, and many more, nanoscale-sized compounds are utilised in cosmetic formulations. Micellar nanoparticles are one of the most recent cosmetics technologiesIt is becoming increasingly well-liked and is being widely sold in both domestic and international markets. The efficient delivery of bioactive chemicals to the skin is made possible by a nanoemulsion technology's ability to produce tiny, highly surface-aread micellar nanoparticles.

1.2 nanotechnologies horizon

The manipulation of materials and technologies at the nanoscale level, which is usually measured in billionths of a meter, is what is known as nanotechnology. This discipline is fast advancing. In fields including electronics, medicine, energy, and environmental science, the field has already developed a wide range of applications.

Many industries, including cosmetics, have been transformed by nanotechnology. One to 100 nanometer-sized particles are used in nanotechnology, and due to their distinctive characteristics, they are highly valuable in the cosmetics industry.

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nanotechnology is being used in cosmetic science for improved delivery for active ingredients, enhanced sun protection, increase stability and shelf life, improved texture and feel, targeted delivery.

1.3 ancient history of nanotechnology

For more than 4,000 years, people have used nanomaterials without fully comprehending the underlying science.

Numerous clay minerals, which have been used for thousands of years in fields including construction, medicine, and the arts, contain natural nanomaterials.

Recent scientific research has also revealed that the lead-based hair dye used in ancient Egypt contains nanocrystals made of lead sulphide.

Nanomaterials are responsible for the beauty of certain historical items. Depending on the illumination, gold and silver nanoparticles in the Lycurgus Cup, a glass cup made in Rome in the fourth century, change colour. The bright colours of the stained glass windows found in many mediaeval cathedrals are also a result of the nanomaterials contained inside the glass.

1.4 natural nanomaterials

Natural nanomaterials come primarily from our planet. Natural activities such as volcanic eruptions, forest fires, dust storms, and sea spray can produce nanomaterials. Numerous nanostructures are also found in humans, invertebrates, and even plants. For instance, because of their nanostructures, lotus flower leaves are water- and self-cleaning. Nano shaped minerals are also present in our bones. Even our DNA, the most essential component of who we are, is a nanomaterial.

Nanomaterials have also been discovered in meteorites that have landed on Earth and are present in other parts of the cosmos, such as cosmic and lunar

1.5 current prospects of nanomaterials

Nanomaterials have a plethora of potential uses, both now and in the future. But we'll focus on two that many businesses find particularly intriguing:

• graphene

• nanocellulose

Numerous businesses, like 2D Carbon Tech, ACS Material, and Advanced Graphene Products, are concentrating on producing and investing in graphene due to its tremendous potential. As an illustration, Saint Jean Carbon declared that it would start producing lithium-graphene batteries in 2017.

Information is essential before making any investments because there have been cautions about the high expectations certain businesses are placing on their products. The increased demand from the paper and pulp industry is expected to help the nanocellulose market reach USD 661.3 M in 2023. The market for electronics and sensors is the one that has the highest predicted compound annual growth rate. Among the businesses in this industry are FPInnovations (Canada), American Process (USA), and Innventia (Sweden).

The cosmetics business has already benefited greatly from nanotechnology, and future developments appear bright. Here are some potential topics for nanotechnology study and development in the field of cosmetic science:

1. Active ingredient delivery: Active compounds including vitamins, antioxidants, and peptides can be delivered via nanoparticles to the deeper layers of the skin. This makes it possible to treat numerous skin disorders more successfully.
2. Sun protection: Nanoparticles can be utilised to make sunscreens that are better at blocking damaging UV rays without producing a white film on the skin.

3. Anti-aging: Nanoparticles can be utilised to make products that promote the creation of collagen and lessen the visibility of wrinkles and fine lines.

4.Skin regeneration: By delivering stem cells and growth factors to injured skin, nanoparticles can be employed to enhance skin regeneration.

5. Diagnosis of skin conditions: Nanoparticles can be utilised to make sensors that can track changes in the pH, wetness, and other characteristics of the skin. This can assist in identifying skin disorders and recommending the best courses of action.

6. Hair care: Nutrients and other helpful elements can be sent to the hair shaft using nanoparticles, which will enhance the health and appearance of hair.

1.6 nanoparticle

The size of nanoparticles, which typically range from 1 to 100 nanometers, is exceedingly small. A wide range of materials, including metals, semiconductors, and polymers, can be used to create them. Nanoparticles are smaller than bigger particles of the same material and have distinctive characteristics and behaviours.

Numerous industries, including health, electronics, energy, and materials science, use nanoparticles. Nanoparticles are being created for use in medicine for imaging and medication delivery. Nanoparticles are employed in electronics to improve the performance of electrical components like computer chips and solar cells. Nanoparticles are being researched for application in batteries and fuel cells in the energy sector. Nanoparticles are utilised in materials science to produce new materials with distinctive features.

1.6.1 different types of nanoparticles

1.6.1.1 carbon-based nanoparticles

Carbon nanotubes (CNTs) and fullerenes make up the majority of carbon-based nanoparticles. Given that they are 100 times stronger than steel, the usage of these nanoparticles usually concentrates on structural reinforcement.

Single-walled carbon nanotubes (SWCNTs) and multi-walled carbon nanotubes (MWCNTs) are two different types of CNTs. Because they are non-conductive across the tube yet thermally conductive along its length, CNTs are special in a way.

Carbon allotropes known as fullerenes have hollow cage structures made up of sixty or more carbon atoms. The Buckminster fullerenes structure of C60 is shaped like a hollow football.

These formations contain pentagonal and hexagonal-shaped carbon units. These commercially useful carbon-based nanoparticles feature electrical conductivity, structure, high strength, and electron affinity.

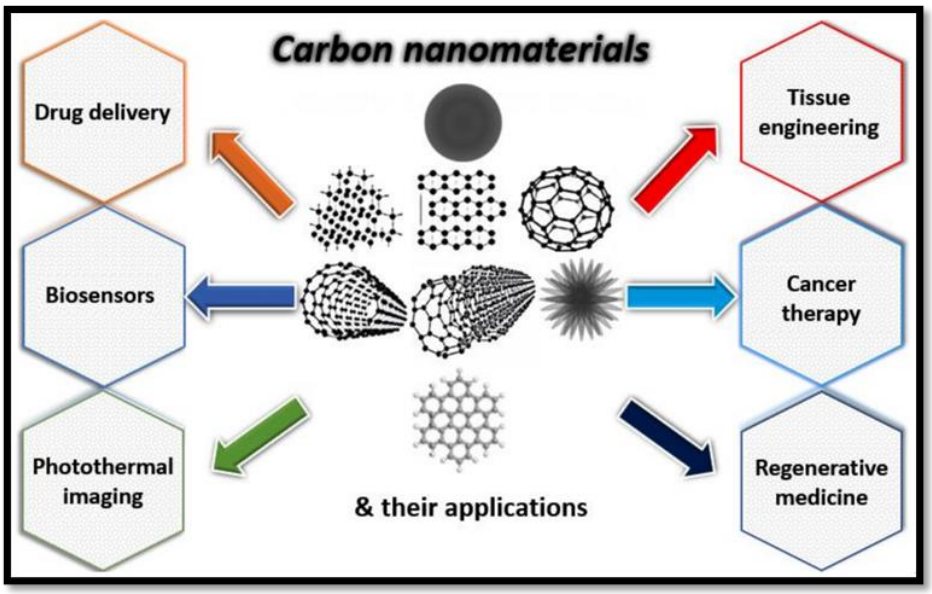

Fig. 1.6.1.1 Carbon based nanomateirals & their applications

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1.6.1.2 ceramic nanoparticles

These solid inorganic nanoparticles are made up of oxides, carbides, carbonates, and phosphates. Ceramic nanoparticles are used in biological imaging, drug administration, photocatalysis, and dye photodegradation because of their great heat resistance and chemical inertness.

Ceramic nanoparticles have been utilised successfully to transport medications for a number of illnesses, including cancer, glaucoma, and bacterial infections.

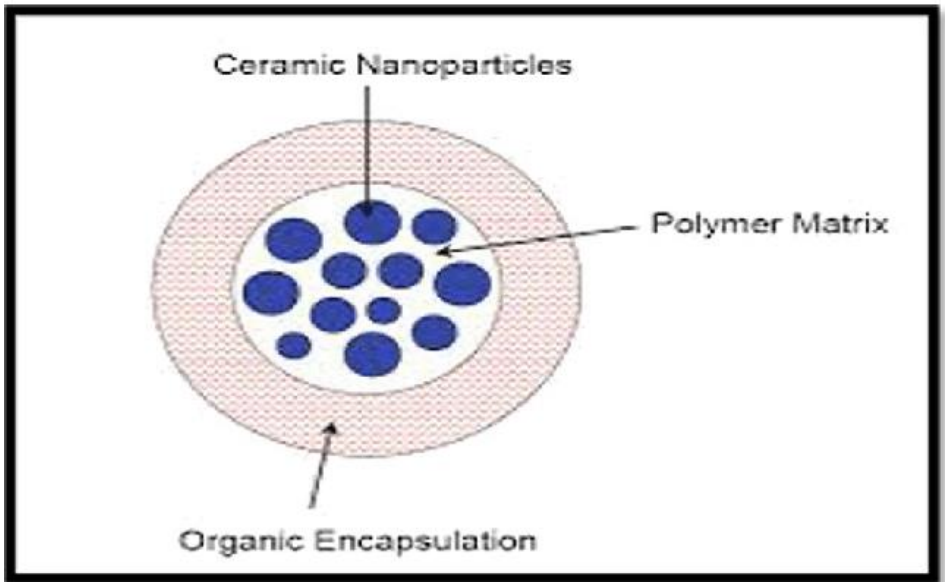


Fig. 1.6.1.2 Schematic representation of ceramic nanoparticles

1.6.1.3 metal nanoparticles

Metal precursors are used to create metal nanoparticles, which can then be produced chemically, electrochemically, or photochemically.

Metal nanoparticles are used in a variety of scientific disciplines, including biomolecular imaging and detection as well as environmental and analytical applications. As an illustration, gold nanoparticles are applied to the sample prior to SEM analysis to improve SEM and create excellent electron microscopy images.

Among the metal and metal oxide nanoparticles (NPs) that may be found in cosmetics, those comprising zinc oxide and titanium dioxide are frequently used as components to achieve an adequate level of sun protection.

Some cosmetic compositions are said to have more potent antibacterial and healing effects after the addition of silver and gold nanoparticles.

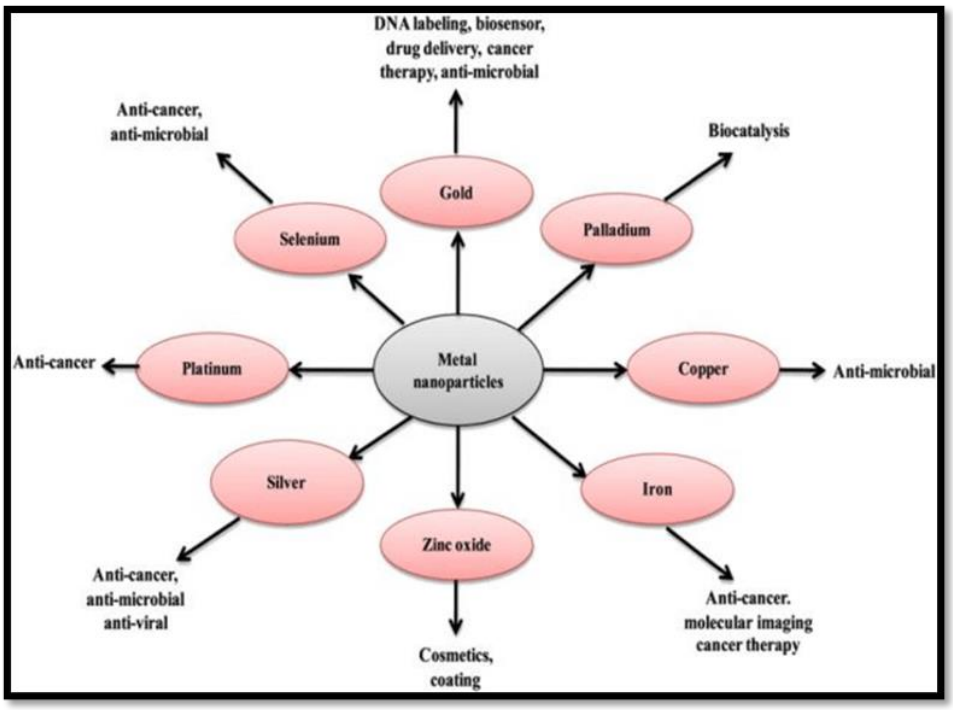


Fig.1.6.1.3 Different types of metal nanoparticles and their applications

1.6.1.4 semiconductor nanoparticles

Semiconductor nanoparticles are found in groups II-VI, III-V, or IV-VI of the periodic table and have properties similar to those of both metals and non-metals. Wide bandgaps in these nanoparticles allow for the tweaking of many properties. GaN, GaP, InP, and InAs from groups III to V are some examples of semiconductor nanoparticles, as are ZnO, ZnS, CdS, CdSe, and CdTe from groups II to VI and silicon and germanium from group IV.

Applications for semiconductor nanoparticles include photocatalysis, electronics, nanophotonics, and water splitting.

1.6.1.5 polymeric nanoparticles

Organic-based polymeric nanoparticles are nanoparticles. Polymeric nanoparticles can be created in the form of nanospheres or nanocapsules, depending on the process. Controlled release, the possibility to combine therapy and imaging, and targeted targeting are a few benefits of polymeric nanoparticles.

Polymeric nanoparticles are used in diagnostic and medication delivery procedures. Polymeric nanoparticle-based drug delivery methods are also exceptionally biocompatible and biodegradable.

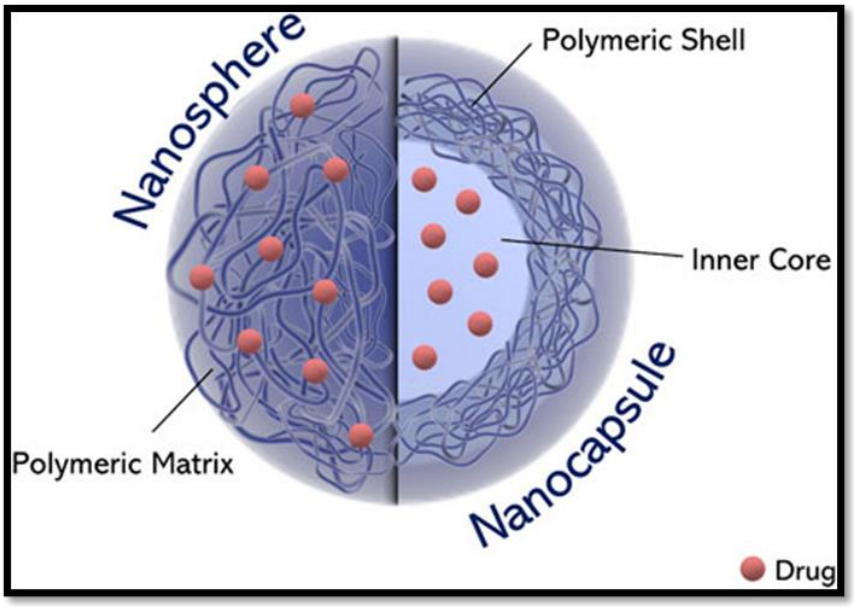


Fig. 1.6.1.5 POLYMERIC NANOPARTICLE

Polymers are employed as emulsifiers in hair dyes .Polymers can be used to enhance the specificity of a pigment's application to hair, minimizing the undesirable effects of concurrent skin colouring and polymers linked to pigments that contribute to the formation of a coloured film on the threads during the hair-washing process.

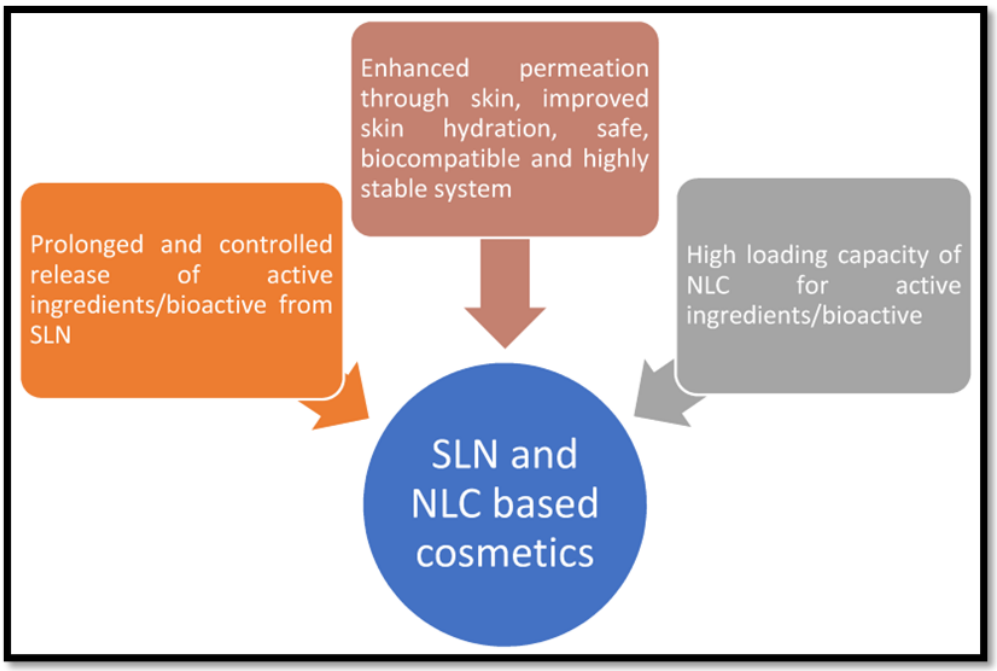
1.6.1.6 lipid nanoparticles

Lipid nanoparticles typically have a diameter of 10 to 100 nm and are spherical in shape. They have a matrix of soluble lipophilic molecules and a solid lipid core, and the exterior core is stabilised by emulsifiers and surfactants.Lipid nanoparticles are used in cancer therapy and as drug carriers in the biomedical industry.

Phosphatidylcholine-based liquid nanoparticles are easily biodegradable. The individual molecular pieces penetrate the skin, but not the whole particles. They consist of:

nanoparticles including ceramides, vitamins, coenzyme Q10, vegetable oils, and vital fatty acids, as well as other active ingredients that are fat-soluble.

Water-soluble vitamins, antioxidants, glycosides, moisturizers, and other ingredients are contained in biodegradable (liquid) liposomes; these nanoparticles are metabolised in a manner similar to other ingredients found in creams and lotions.



1.6.1.6 Uses of solid lipid nanoparticles and nanostructured lipid carrier based cosmetics

2. NANOTECHNOLOGY IN COSMETICS

2.1 introduction

"Particles intended to be applied onto human bodies or any part thereof for cleansing, beautifying, promoting attractiveness, or altering the appearance" (U.S. Food and Drug Administration, 2018). According to Gautam et al. (2011), cosmetics are products that enhance the appearance and beauty of the skin as well as deepen cleansing. According to above definitions, Thornfeldt (2005) described the categories of cosmetics such as skin moisturizer, facial makeup,shampoo,deodorant,hair colour,tooth paste,anti-aging cream and other goods that were meant to enhance one's appearance (Thornfeldt, 2005).

Many water based cosmetic formulation including facial cleanser, makeup removers and anti-aging lotions uses oil in water based nanoemulsion which is very important in formulation. This review's main goal is to provide a comprehensive analysis of the characteristics, benefits, and mechanism underlying micellar nanoparticle creation in nanoemulsion systems. Therefore, the aim of this article is to introduce and discuss the special advantages of using a nanoemulsion technology to create micellar nanoparticles for cosmetic formulation. These advantages are significant for the continued growth of the micellar-based cosmetic market.

In order to attain specified features and functionalities, nanotechnology entails altering materials at the nanoscale level, which is exceedingly small. Nanotechnology has been used in the study of cosmetics to create novel and beneficial goods that can help customers more.

The creation of nanoparticles that can more efficiently penetrate the skin and hair follicles than conventional chemicals is one of the main uses of nanotechnology in beauty research. This makes it possible for active compounds to be more effectively absorbed and retained, producing outcomes that are more focused and effective. Additionally, new textures and formulas, such as light and non-greasy creams and lotions, can be made using nanoparticles. The stability and shelf-life of cosmetic goods can be increased with the use of nanoparticles, which can also lessen the need for preservatives.

The use of nanotechnology in cosmetic goods, however, raises questions regarding its safety and potential health consequences. The safety concerns of the nanoparticles which are used in cosmetic products must be ensured, as must their limited absorption into the skin and body.

2.2 nanomaterilas used in cosmetics

Nanomaterials are widely used in cosmetics due to their unique physicochemical properties. Some examples of nanomaterials which are commonly used in cosmetics include:

1. Nanoparticles of zinc oxide and titanium dioxide: Due to their potent UV-ray absorption, sunscreens frequently contain these nanoparticles. In comparison to their non-nano counterparts, they also have smaller particle sizes, which facilitate skin absorption.

2. Silver nanoparticles: Due to their antibacterial qualities, silver nanoparticles are beneficial in cosmetic products including toothpaste, deodorants and face creams.

3. Gold nanoparticles: By lessening the visibility of fine lines and wrinkles, gold nanoparticles are utilised in cosmetics to improve the appearance of the skin.

4. Clay minerals in the form of nanoparticles: These particles are used to face masks to help absorb extra oil and enhance the texture of the skin.

It's important to note that the use of nanomaterials in cosmetic products has raised concerns about their potential health and environmental effects. studies have suggested that certain nanomaterials may be toxic or have negative impacts on the environment. Therefore, it is important for manufacturers to thoroughly evaluate the safety and potential risks associated with the use of nanomaterials in cosmetics.

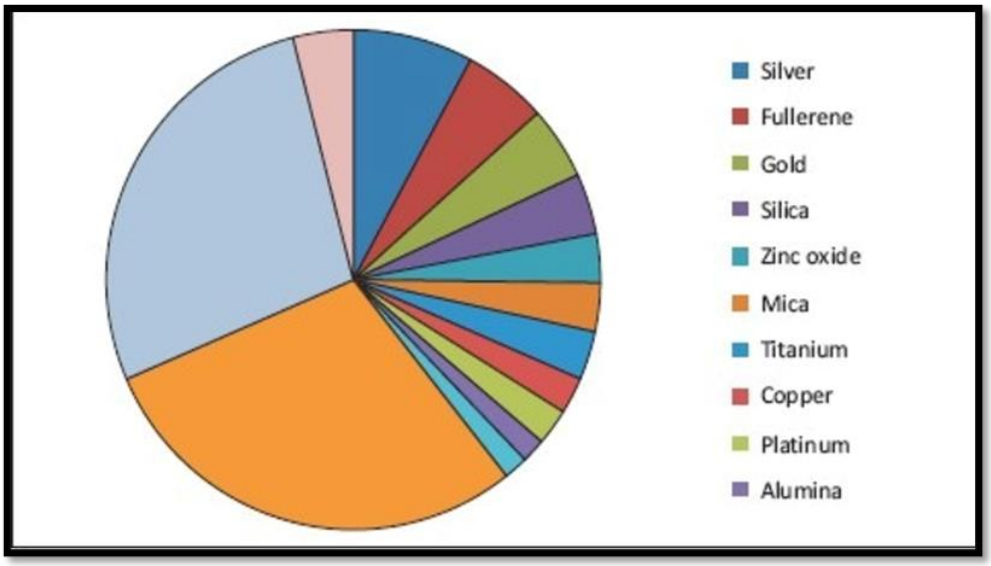


Fig. 2.2 GRAPH: Principle nanomaterials used in cosmetics

3. NANOFORMULATIONS IN COSMETICS

3.1 liposomes

In essence, liposomes are spherical containers with an aqueous centre that are predominantly made of bilayered phospholipids that can be obtained from both natural and artificial sources, including cholesterol. These structures are highly biocompatible, biodegradable, and non-toxic due to their comparable chemical make-up to biological membranes. These qualities make liposomes simple to make, quickly penetrate into the skin, and useful for delivering active pharmacological substances. Liposomes are efficient dermal transporters due to their tiny size, unilamellar structure, and flexible membrane architecture. Due to this characteristic, liposomes are commonly used in cutaneous applications to protect active ingredients or to benefit from their moisturising characteristics.

The lipids themselves contain the moisture needed to produce liposomes. As a result, moisture sticks to the skin's surface and hydrates it when the liposomal vesicle bursts. Liposomes are a great option for cosmetic compositions meant for dry skin because of their qualities. Lipid vesicles produce an occlusive coating that sticks to the skin's surface and offers extra advantages. In addition to protecting the skin's cells from environmental stresses like sunlight and perspiration, this occlusion also improves the skin's ability to absorb encapsulated active ingredients. The use of liposomes makes it easier to deliver active ingredients in cosmetic products to the necessary outer or deeper skin layers, such as aqueous sun care solutions with liposome-encapsulated UV filters.

3.1.1 the following steps are included in the standard process for creating liposomes

1. Separating the organic solvent from the lipids that it produced.
2. The dried lipids' dispersion in an aqueous solution.
3. The final liposome solution's refinement.
4. Assessing the final product for its qualities and assurance of production.

3.1.2 adavantages of liposomes in cosmetics

1. To reduce the potential side effects and irregularities that may arise from its targeted drug delivery properties, thereby decreasing systemic retention.
2. The mimic epidermis's structure allows liposomes more inclined to stick to organic layers, which improves drug absorption through the skin.
3. Liposomes' nontoxic, biodegradable and recyclable qualities.
4. Straightforward to upscale for production needs.
5. To combine active substances that are both hydrophilic and hydrophobic.
6. Able to give water of a safe quality while being capable of preventing leaching.
7. Enables the targeted distribution of active substances to the skin, resulting in a continuous and dynamic release of the chemical, boosting sedative efficacy and lowering risk profiles at the targeted location. In addition to their distinctive benefits, liposomes have a number of disadvantages, including a lengthy shelf life, a high production cost, a difficult manufacturing procedure, a vulnerability to hydrolysis or oxidative destruction, and a propensity to settle, aggregate, or mix with liposomes of inadequate size.
8. Liposomes have applications in the treatment of diverse ailments like vitiligo, psoriasis, hirsutism, and atopic dermatitis.

3.1.3 disadvantages of liposomes in cosmetics

1. Expensive manufacturing technology.
2. During production, phospholipids are vulnerable to oxidation and hydrolysis.
3. Drug encapsulation may result in leakage and fusion.

3.1.4 marketed formulations of liposomes

1. **C-Vit Facial Liposomal Serum** is a face serum marketed by the company Sesderma India Pvt Ltd and benefits include boosting skin brightness, enhancing complexion, and minimising dark circles.

2. Parcos markets Valmont Hydra3 Regenetic, a facial cream that offers advantages such as exfoliating the skin, eliminating impurities, and acting as a makeup remover.

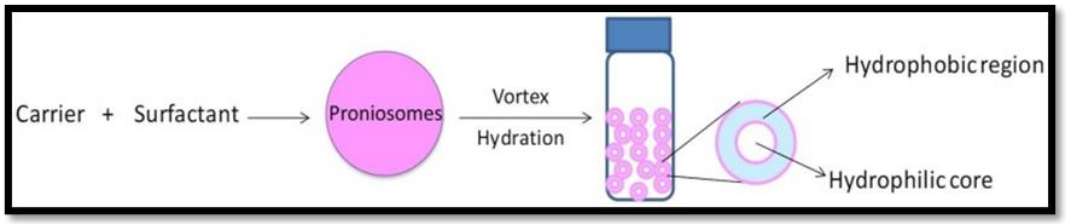
3.2 niosomes

Composed of aqueous, non-ionic surfactants and cholesterol, these nanoscale vesicles are referred to as niosomes. Niosomes are particularly effective for transporting pharmaceuticals or active ingredients that possess hydrophilic, lipophilic, and amphiphilic properties. Tween and span are the non-ionic surfactants used in niosomes. These non-ionic surfactants, in particular, are formed when the right quantity of cholesterol is added to the mixture of polysorbate 80 (HLB value: 15) and tween 20 (HLB value: 16.7). Alternatively, niosomes can be produced at the same level of cholesterol using simply tween 20.

Niosome synthesis is significantly influenced by the composition of nonionic surfactants, which are typically composed of one or more lamellae. These lamellae consist of bilayers with hydrophilic and hydrophobic components linked by ester, ether, or amide bonds.

3.2.1 preparation of niosomes

1. Proniosomes: Proniosomes, which are essentially dried niosomes, are used in one popular type of niosome formation. Niosomes can be formed from protosomes by rapidly hydrating them.



1. Sonication: The process of sonication, which is frequently employed to prepare niosomes, is simple to use. In order to create niosomes, an appropriate mixture of non-ionic surfactant is combined with the drug solution (in buffer) at an optimised ratio. The mixture is then subjected to sonication at a selected frequency, temperature, and time.
2. Micro fuidization method: Niosomes are produced using an innovative process of microfluidization. Fluids like water and alcohol are mixed together in tiny channels in this process. The required particle sizes and size distribution of niosome formulations can be accomplished by controlling elements like surfactants, mixing conditions, and other components.
3. Thin film hydration method- The preparation of niosomes using the thin-film hydration (TFH) method involves placing the membrane-forming components and an organic solvent in a flask. After vacuum evaporation to remove the solvent, a thin-film layer forms inside the flask. The dry film is hydrated by dissolving the drug in an aqueous solution, such as water or a buffer. The mixture is incubated in a water bath at a temperature above the surfactant's transition point, resulting in the formation of multilamellar vesicles (MLVs) niosomes using the TFH approach. This is a simple process with the potential to produce niosomes with various compositions and characteristics.

3.2.2advantages of niosomes

The niosomes' aqueous solution can contain functional cosmetic chemicals that can be dissolved or distributed to deliver them to particular areas (targeted delivery) or at a set rate (controlled delivery). The aqueous core and membrane bilayer of niosomes allow for the encapsulation of hydrophilic and lipophilic medications

3.2.3 disadvantages of niosomes

1. Physical instability: Niosomes can undergo physical instability, leading to changes in size, shape, and structure, which can affect drug delivery efficacy.
2. Aggregation or clumping of encapsulated drug.
3. Leakage: the entrapped drug may leak from the noisome formulation.
4. Hydrolysis: the hydrolysis of the encapsulated drugs can limit the shelf life of the dispersion.

3.2.4 structure of niosome

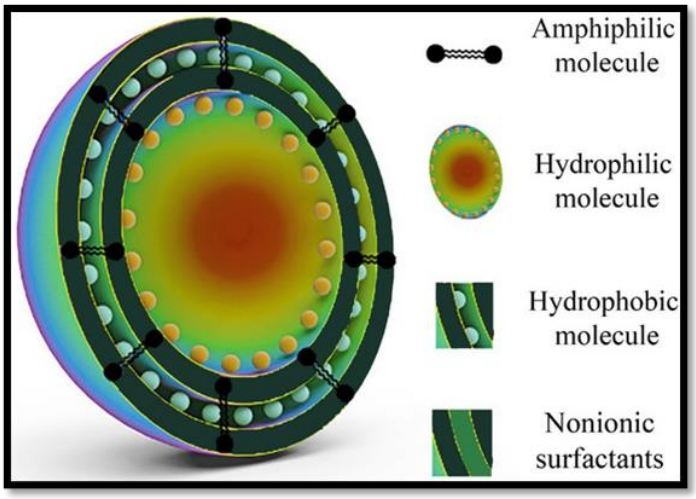


Fig. 3.2 Structure of niosome

3.2.5 marketed formulations of niosomes

1. Niosome+ : Lancome's foundation cream, Niosome+ provides benefits of anti ageing therapy along with skin rejuvenation.
2. Eusu Niosome Makam Pom whitening facial lotion is a product marketed by Eusu, a south Korean company offers advantages such as skin whitening and increasing radiance of the skin.

3.3 nano emulsions

Systems known as nanoemulsions are not thermodynamically stable, and the method of preparation can change the structure of these systems. They are made up of little droplets of one liquid scattered throughout another. The most cutting-edge nanomaterials currently being employed in the manufacture of cosmetics are nanoemulsions.

Nanoemulsions are made up of two phases, an oil phase and a water phase, which are dispersed as submicron droplets throughout one another and stabilized by surfactants. Due to their fine texture, they can be sprayed on and are relatively stable. They are recognized for their ability to penetrate and hydrate the skin effectively.

3.3.1 method of preparation of nano emulsions

Nano emulsions are commonly prepared by two distinct methods:

i) High-pressure homogenization- It involves applying high pressure to the product tank to produce uniformly sized, tiny particles that are about 1 nm in size.

ii) Microfluidization- it is a mixing device with high pressure. It is made up of micro channels. It receives the product and filters it to produce a nanoemulsion with a small, uniform particle size.

3.3.2 advantages of nano emulsion in cosmetics

1. Because of their vast surface area and compact size, nanoemulsion droplets are beneficial in cosmetics because they can disperse active chemicals to the skin more effectively. Compared to conventional emulsions, they are more useful in cosmetology because they have low viscosity and don't serve as flocculants, coalescing agents, creaming agents, or sediment-producing chemicals.

2. Additionally, in order to reduce trans-epidermal water loss, offer dermal protection, and improve the penetration of active chemicals, nano-emulsion technology has been proposed for use in a variety of cosmetic products, including moisturisers, anti-aging creams, and sunscreens.

3.3.3 disadvantages of nano emulsions

1. Despite having various advantages of nanoemulsions in cosmetics, it has its shortcomings, number one being, nano emulsions aren't thermodynamically stable at all.
2. Because of small particle size of 100nm or less, these systems have various instability issues which may result in the collapse of formulations.
3. Nanoemulsions have limited thermodynamic stability and are often referred to as "kinetically stable" in the long term due to their tendency to aggregate. The small droplets in nanoemulsions are susceptible to irreversible destabilization due to mechanisms such as Ostwald ripening or coalescence.
4. Nano emulsions can not be formulated for poorly soluble drugs or excipients.

3.4 solid lipid nanoparticles

The spherical solid lipid nanoparticles (SLNs) have an average diameter of 50–1000 nm. They are solid at body temperature and made of lipids and surfactants. SLNs have demonstrated encouraging results in accelerating the entry of active substances into the skin and are biocompatible and non-toxic. They can also enable long-term regulated release of aesthetic chemicals while shielding the encapsulated compounds from deterioration.

In vivo investigations show that an SLN-containing formulation is superior than a placebo in terms of skin hydration. The two types of solid lipid nanoparticles are nanospheres and lipospheres.

3.4.1 advantages of sln in cosmetics

i. SLNs can be used as carriers for both pharmaceutical and cosmetic substances when coupled with nanostructured lipids. They are a potential delivery strategy because they have good physical stability and a low rate of medication leakage.
ii. The advantages of several colloidal systems, including liposomes, nanoemulsions, and polymeric nanoparticles, are provided by SLNs.
iii. SLNs are thought to be non-toxic to living things since they make use of lipids that are both biocompatible and biodegradable.
iv. They can be made using a solvent-free technique, which is safer for people and less harmful to the environment, than the techniques that use organic solvents.
v. Drug targeting and regulated drug release are both possible with SLNs.
vi. Adding active substances to SLNs can increase their stability.
vii. SLNs can be sterilized easily.
viii. SLNs exhibit excellent physical stability.

3.4.2 disadvantages of slns in cosmetics

1. Aside from the issue of having an immaculate crystalline structure, SLNs also have a low drug loading efficiency, the potential for drug expulsion due to crystallisation during storage, and other drawbacks.
2. Under unfavourable storage conditions, SLN can transform into polymorphic forms, which can alter the medications or cosmetic chemicals in there release.
3. Water is widely distributed in lipid dispersions.
4. Transdermal drug administration with limits.
5. Hydrophilic drugs have limited loading capacity in SLNs.
6. Lipid nanoparticle toxicity on retinal cells has not yet been properly studied.

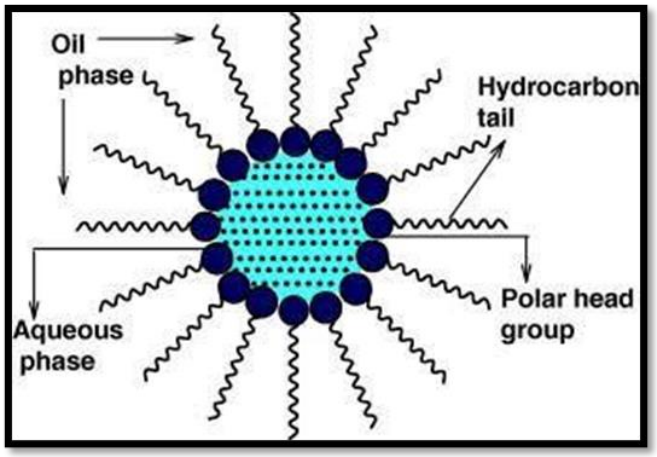
3.4.3 marketed formulations of solid lipid nano particles

1. A product marketed by the company Q10, named- Q10 Nano Anti-Ageing Cream is an anti ageing regenerating cream that exhibits advantages of anti ageing as well as anti wrinkle and rejuvenation properties.
2. Eye serum named a Biolumin-C Eye Serum, a product of Dermalogica, an Indian dermatological company, reduces the appearance of fine lines and wrinkes.
3. Nanovital cream is a product with anti ageing properties along with UV protection, also showcases properties of anti oxidation and cooling effect on the skin.

3.5 Micelle

When the concentration of surfactants in an aqueous solution exceeds the critical micellar concentration, micelles are formed. These micelles, which are less than 100 nm in size, can be utilized as nanomaterials to formulate drugs or cosmetic agents with low solubility as colloidal solutions.

3.5.1 structure of micelle:



3.5.2 benefits of micelles in cosmetics

Micelles' amphipathic properties are used in skincare products to create softer, more moisturising face cleansers. Micelles surround and take away dirt, oils, and pollutants when applied to the skin's surface. By using this technique, you may avoid using harsh detergents and chemicals that could dry out your skin. Products that clean with micellar water are effective at removing grime and makeup while sparing the skin's natural oils.

3.5.3 micellar nanoparticles in nanoemulsion system

Micellar nanoparticles can be produced by certain types of nanosystems, such as nanoemulsion systems. They are thought to be the most efficient way to make micellar-based cosmetics. A nanoemulsion is a clear or translucent mixture of two immiscible liquids that includes active chemicals scattered in nano lipid droplets. An O/W emulsion is one type of nanoemulsion. Surfactants stabilise these droplets and arrange them into micelles or micellar nanoparticles.

Compared to other types of emulsions, nanoemulsions (specifically O/W nanoemulsions) have superior properties for cosmetic use due to their ability to form smaller micellar nanoparticles (ranging from 10-200 nm). These smaller particles allow for more uniform distribution on the skin, improved delivery of active ingredients, greater stability, a larger surface area, and a more pleasing aesthetic and skin feel. The strong thermodynamic and kinetic stability provided by the smaller micellar nanoparticle size also protects against flocculation, sedimentation, and the Ostwald ripening phenomenon, making nanoemulsion-based cosmeceuticals highly effective.

3.5.4 marketed formulations

Product name	Marketed by	Use
Sensibio H20 micellar cleansing water	Bioderma	Make up remover
Garnier skin active micellar water	Garnier	Make up remover and soothing agent

4. NANOTECHNOLOGY COSMETICS: MARKET STUDY

Numerous studies have shown that most major cosmetics manufacturers incorporate nanotechnology in many of their products. In 2006, the world's largest cosmetics company, Estee Lauder, entered the nanomarket with a line of products featuring "NanoParticles." L'Oreal, the world's largest cosmetics company, has patented the use of several "nanosome particles" and is investing approximately $600 million of its $17 billion in annual revenue in nanopatents. It holds the sixth-most nanotech patents in the United States. Other examples include Freeze 24/7, Doctor's Dermatologic Formula, and Colorescience.

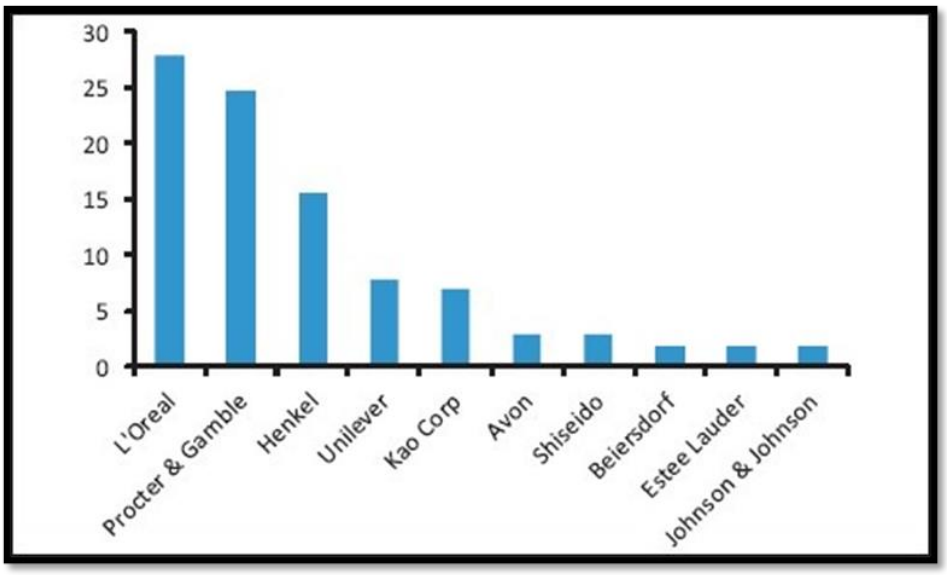


Fig. 4.1 Ranking of top 10 beauty companies in terms of number of nano-related patents

(Ref- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3425166/)

5. SAFETY CONCERNS WITH NANOCOSMACEUTICALS

Nanotechnology has gained widespread attention in the cosmetics industry due to its potential to increase the efficacy of cosmetic products.Nanoparticles have certain qualities that make them perfect for usage in cosmetics,such as enhanced surface area and reactivity. However, concerns about potential health risks have been raised by the use of nanotechnology in cosmetics.

The main issue with cosmetic nanoparticle safety is whether or not they can enter the bloodstream either during production or during use. If they do, there might be unfavourable effects. When the Food and Drug Administration (fda) nanotechnology taskforce published recommendations for regulatory consideration with an emphasis on the security and lack of adulteration of cosmetic products, In the USA, the demand for nanomaterial safety increased. Two primary pieces of information (stratergies) are required for the FDA to evaluate the safety of nanoparticles in cosmetics.

One stratergy is details on the material's characteristics,notably its utilisation of nanotechnology. Such characteristics, their biological interactions, and a characterisation of any associated contaminants will be included in information on such materials as well as the finished cosmetic products, as nanoparticles may have changed the physicochemical properties. Experts in health and safety can better manage incidents of contamination, allergies, or poisoning with use of precise and readily available information.

The second of these details is the product's toxicological information. This can be determined by testing the cosmetic chemicals for systemic toxicity (acute,chronic,subchronic), skin sensitivity,photosensitivity,and photoallergy. The toxicological hazard of repeated use of particular products or cumulative exposure to comparable compounds. In addition, information on genotoxicity,foetal toxicity,carcinogenicity assessment, and impairment to reproductive health will be required.

There are two ways that people are exposed to nanomaterials.

The manufacturers: High nanomaterial concentrations are routinely inhaled by workers in cosmetic production plants. This is especially true if necessary safety precautions are not put in place or are not followed in such a working environment, since numerous microscopic nanoparticles will be released into the air at the production location.

The consumers: The consumers might be individuals who use the product directly or those who come into touch or have a relationship with direct (or primary) users who utilise it. Nanoparticles in lipsticks, skin care products, and scents may be transferred to secondary users by simple gestures like an embrace or a kiss. Three potential entrance sites for nanoparticles into consumers are; Ingestion, whether deliberate or inadvertent, of lip and near-mouth goods (lip gloss, lip paints, mouth fresheners), inhalation of sprayed products (fragrances), furthermore using skin care products on the skin. Due to their size, inhaled nanoparticles can enter the alveolus, the functional component of the respiratory tract. contacts the respiratory epithelium's membrane with great affinity. They most likely will pass via the olfactory epithelium, with some going through the nasal nerves and into the brain and others going through the circulatory system and into other organs. According to reports, just a little amount of the swallowed nanoparticle is taken up by the bloodstream. Through faeces, the greater portion exits the body from the gastrointestinal system.

The body's biggest organ, the skin, is the main organ through which cosmetic goods are absorbed, particularly when applied directly. However, when it is whole, its outermost layer acts as a useful barrier that seems impenetrable since it is lipophilic and has strong cell cohesion. There is no conclusive proof that nanoparticles can penetrate deeper layers of skin, despite several studies being done to determine the degree of their penetration through intact skin.

There are several studies done on nanoparticle that how will it affect the skin, which are discussed further.

1. Penetration of nanoparticles into the skin: Nanoparticles used in cosmetics have the ability to pass through the skin and into deeper tissues, including the bloodstream. Concerns are raised concerning the possible health dangers linked to the usage of nanoparticles in cosmetics as a result. According to certain research, nanoparticles can build up in organs including the liver, spleen, and lungs, which might have a negative impact on one's health. Moreover, The likelihood of skin irritability, allergies, and other negative consequences may rise as a result of nanoparticle penetration into the skin.

2. Toxicity: A significant worry is the toxicity of nanoparticles used in cosmetics. The chance of developing cancer and other diseases may rise as a result of certain nanoparticles' ability to cause cellular damage, oxidative stress, inflammation, and genotoxicity. Nanoparticle toxicity is influenced by a number of variables, including size, shape, surface area, and surface charge. In order to properly assess the safety of nanoparticles used in cosmetics, it is essential to consider these factors.
3. Environmental impact: The usage of nanotechnologies in cosmetics may have negative effects on the environment. Wastewater has the potential to unleash nanoparticles into the environment, endangering aquatic life and ecosystems. Long-term ecological implications from the buildup of nanoparticles in the environment might include modifications to microbial populations, bioaccumulation, and nutrient cycling.
4. Lack of regulation: The use of nanotechnologies in cosmetics is not yet governed by any laws. Consumers find it challenging to make educated selections since businesses are not compelled to provide safety information about the nanoparticles used in their goods. Sometimes businesses won't even admit to using nanoparticles in their goods.

because there is little transparency and regulation, it is difficult to assess the safety of nanoparticles used in cosmetics.

For the example, The International Cooperation on Cosmetics Regulation (ICCR) has released guidelines for evaluating the safety of nanomaterials in cosmetic products. a voluntary worldwide association of regulatory bodies. The recommendations offer a framework for evaluating the safety of nanomaterials, and they advise businesses to do a thorough risk analysis that takes the nanomaterials' potential for exposure, toxicity, and environmental effect into account.

5. Alternatives: It's critical to consider other solutions given the possible health dangers related to the usage of nanotechnologies in cosmetics. Natural and organic components are some options that may be less hazardous to the environment and people. Additionally, improvements in environmentally friendly chemistry and manufacturing might present safer and more sustainable substitutes for nanotechnologies.

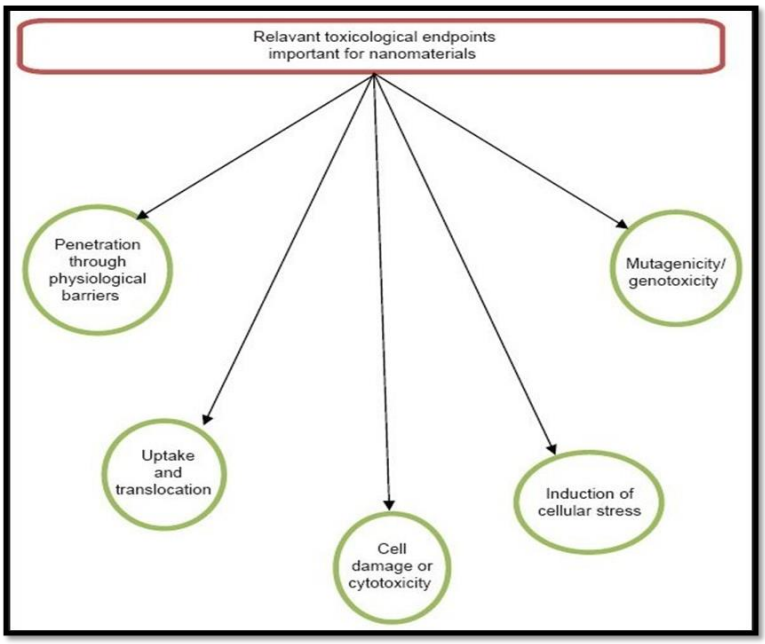


Fig. 5.1 Relavant toxicology endpoints important for nanomaterials

http://ec.europa.eu/health/ph_risk/committees/04_sccp/docs/sccp_o_099.pdf

Nanoparticles are harmful and have the potential to harm DNA, according to the 2007 Annual Conference of the American Society for Disease Research. University of Massachusetts researchers claim that nanoparticles are both tiny enough to pass through the cell wall and big enough to fit inside a normal cell. They are so tiny, according to Sarah Pacheco, a researcher at the University of Massachusetts, that it is challenging to isolate them using conventional isolation techniques, which can destroy healthy cells and inflict potentially fatal harm. Said. It reads. However, because to the low estimates, it might be difficult to properly verify how they relate to the environment and affect human well-being.

Another aspect of harmlessness is injury to infants, and increasing this waste can injure expectant mothers excessively. The placenta, endometrium, yolk sac, and newborn may experience oxidative stress and inflammation as a result of some nanoparticle uses.

Placental injury, neonatal dysgenesis, foetal abnormalities, neurotoxicity, and insufficient neonatal regeneration are some of the potential effects of these issues. Moreover, nanoparticles can infect the fetus and impede the development of the frontal lobe by causing the cytokine erain pregnant women.

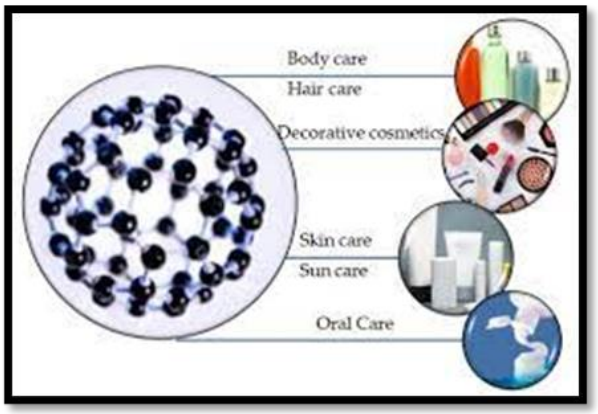
6.CURRENT TRENDS UNDER THE NANOTECHNOLOGY DRIVEN COSMETICS/COSMECEUTICALS

Nanotechnology is being applied to the cosmetics sector to produce goods that carry active substances to the skin more successfully, as well as to enhance the texture, stability, and look of these goods. To increase the efficacy and skin penetration of cosmetics and cosmeceuticals, nanoparticles, nanofibers, and other nanostructures are being added.

Anti-aging creams (Olay Regenerist Micro-Sculpting Cream), sunscreens (Neutrogena Ultra Sheer Dry-Touch), skin-whitening treatments, and hair care items are a few examples of cosmetics/cosmeceuticals that use nanotechnology. These goods include nanoscale components including liposomes, nanoparticles, and nanoemulsions that are made to increase their potency and deliver superior outcomes.

The beauty industry is seeing an increase in the use of nanotechnology-driven cosmetics and cosmeceuticals because they may provide a number of advantages, including tailored delivery of active ingredients, greater product stability, and improved skin penetration. For example Using nanocarriers, which are small particles that may deliver active chemicals to certain skin regions. Before these items are widely used, it is crucial to rigorously assess their efficacy and safety, as with any newly developed technology.

There are many methods and studies have been conducted for enhanced use of nanoparticles & nanomaterials which is discussed further.



https://www.mdpi.com/2079-4991/10/5/979

Fig.6 Different category of products used in nanocosmaceuticles

1. Encapsulation technology: One of the most often utilised forms of nanotechnology in cosmetics is encapsulation technology. Using this method, active compounds are enclosed in nanocarriers, enabling regulated and precise delivery of the contents to the appropriate region of the skin. In order to increase the efficacy of skincare products like sunscreens and anti-aging creams, encapsulation technology has been applied.

2. Nanofibers: Another way that nanotechnology is used in cosmetics is through nanofibers. They are extremely fine fibres that may be used to skincare products to provide further advantages. For instance, nanofibers derived from silk or hyaluronic acid can help to enhance the skin's texture and elasticity, while collagen or hyaluronic acid-based nanofibers can aid to hydrate and plump the skin.

3. Nanopeptides: Nanopeptides are tiny proteins that have been designed to have particular qualities, such better penetration and greater stability. They can be used in cosmetics to address particular skin issues including wrinkles, pigmentation, and acne. Because they can pass through the skin's barrier and transport the active substances to the skin's deeper layers, nanopeptides are highly effective.

4. Nanosensors: Nanosensors are extremely small components that can recognise and react to changes in the skin's pH, temperature, or moisture content. They can be used in cosmetics to monitor the state of the skin in real-time and modify the formulation as necessary. For instance, a moisturiser equipped with nanosensors may modify the degree of hydration it provides dependent on the moisture content of the skin.

5. Nanoliposomes: The lipid bilayer that makes up nanoliposomes allows them to include both hydrophilic and hydrophobic active substances. To enhance the distribution of active chemicals to the skin, these liposomes have been used to cosmetics. They are more effective than conventional compounds in penetrating the skin's barrier, increasing absorption and effectiveness.

6. Nanocapsules: Similar to nanoliposomes, which are tiny vesicles that can encapsulate active chemicals, nanocapsules are likewise small vesicles. Nanocapsules, in contrast to liposomes, contain a solid core and a polymer or lipid shell. The stability and shelf life of the active ingredients can be increased because to this design's more regulated active ingredient release.

7. Nanoparticles in Hair care: To increase the effectiveness of hair care products like shampoos and conditioners, nanoparticles are also employed in these products. For instance, hair damage can be repaired by penetrating the hair shaft with nanoparticles comprised of keratin or silk, resulting in smoother, shinier hair.

8. Nanomaterials for sustainability: Additionally, environmentally friendly and sustainable cosmetics are being created using nanotechnology. An example of a biodegradable substance that may be used as a thickener in cosmetics is nanocellulose, which is manufactured from plant fibres. This substance is a biodegradable, renewable, and appealing replacement for synthetic thickeners.

A developing trend, the use of nanotechnology in cosmetics and cosmeceuticals has various advantages, including improved active ingredient distribution, increased product stability, and better texture. Other new developments in nanotechnology-driven cosmetics and cosmeceuticals, in addition to the ones already mentioned, include the use of nanoporous materials, nanofibers, sunscreen-related nanomaterials, customised nanocosmetics, and nanoencapsulation of scents. With the development of nanotechnology and the discovery of new applications, these tendencies are probably going to continue to increase.

7.FUTURE ADVANCEMENT : DIRECTION FOR FUTURE USE, FUTURE HORIZON

Nanotechnology offers the ability to develop and innovate formulations and delivery systems.This rapidly growing technology has seen extensive usage in both therapeutic and diagnostic purposes. the utilisation of nanotechnology in cosmetic products is currently a largely unexplored but extremely potential field. it has been demonstrated that using nanotechnology in cosmetic formulations can both eliminate the problems with conventional cosmetics and increase their usefulness.

inclusion of nanomaterials has been found to increase product's performance and customer happiness in the field of nanocosmetics and nano cosmeceuticals for the skin, hair, nails, lips, and the teeth. As a result, nano cosmeceuticals are replacing many conventional cosmeceuticals. cosmeceuticals are currently regarded as one of the personal care industry's fastest-growing categories, Furthermore, the market for personalized concern is rapidly rising. It is one of the most rapidly growing businesses, necessitating an increase in nano cosmeceuticals studies, exploration, and uses.

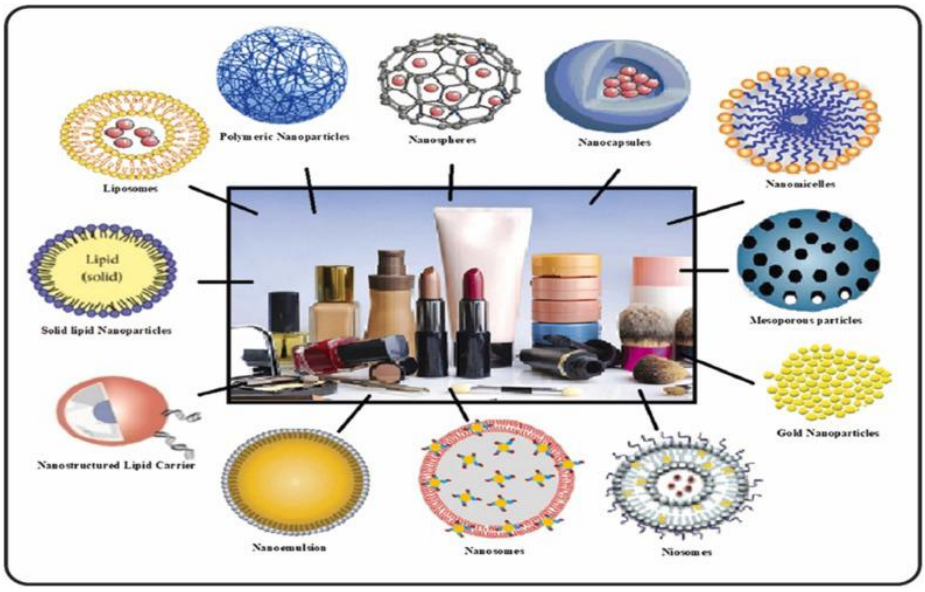


Fig 7.1 Various materials used in nanocosmetics in future

(Ref:www.deloachindustries.com)

7.1 future-oriented goal

In the cosmetic sector, nanomaterials are available in a number of forms and dimensions. Although having been proven that nanotechnology has been employed in cosmetic formulations for a long time, only a few technologies have been used. The limited use of nanotechnology-based cosmetic goods is due to several institutions' limitations and halts on their use. These are the key reasons why many companies are cautious to use nanotechnology in cosmetics .

Green and sustainable nanoparticle synthesis is being investigated by scientists in order to lessen the environmental risks connected with physiochemical syntheses . The long-term objective is to discover the most safe and most acceptable nanomaterial for use with a wide range of aesthetic purposes at the lowest possible price. Because of existence of important features of The nanomaterials and nanotechnology fields have been a increasing to a greater size, as evidenced by a significant number of papers in this sector.

Some extremely promising delivery systems with a wide range of practical uses are being studied. Carbon nanobuds are a one-of-a-kind nanomaterial that combines the characteristics of nanotubes of carbon and fullerenes. They are made by mixing the two most commonest carbon allotropes, fullerenes and carbon nanotubes. Carbon nanotubes are covalently attached to fullerene like "sprouts or buds". They have exceptional field producing characteristics. This could be very useful in the production of lipstick and mascara.

The future will reveal the primary following trends and demands in the nanocosmetics areas. It is becoming obvious that the ability of manufacturers to capitalise on breakthroughs in nanotechnology will determine the sector's future viability. The use of nanotechnology and the connections between inner health, ,and antiaging and beauty products will be one of the most prominent trends in the coming years. a result of this , the use of nanotechnology in cosmetics is vital, the adverse repercussions need to be addressed before adopting nanomaterials.

Toxicity research, and also the effects of different nanomaterials used in the industry on the environment and human well-being.

7.2future directions

The use of engineered nanomaterials has increased in the modern world. Because of its increased qualities, it has grabbed the interest of the cosmetic industries, which are shifting their focus from cosmeceuticals to nano-cosmeceuticals by incorporating nanotechnology into the bulk of their manufacturing processes. But , there is considerable worry regarding the health risk of these nanocosmetics for both people and the surroundings. To assure both the safety and effectiveness of such items, one must consider the most current adjustments made by regulatory agencies from time to time . Furthermore, as nanomaterial technology advances, such changes in regulatory criteria for enhanced safety assessments for these developed cosmeceutical goods become increasingly prevalent.

Nanomaterials are utilized in cosmetics for a variety of purposes. However, their use presents possible safety concerns. Some of those worries can be alleviated by assessing the types of nanomaterials utilized, along with their long-term stability, skin absorption capacity, route of the exposure, and formulation in cosmetic goods. Internationally, there has been significant attempt to harmonize techniques in with the objective to overcome definitional challenges as well as safety concerns connected to the usage of nanoparticles in cosmetic goods.

Furthermore, the new 2019 European guidance for the evaluating safety of nanomaterials in cosmetics,as well as the new suggested technique for nanomaterial toxicity assessment, are given special attention. Health concerns have limited the use of nanoparticles in cosmetics,and because innovative nanoparticles can be used in cosmetic sector in the future, extensive characterisation and risk evaluation are required to meet conventional safety requirements.

SCCS: Safety Assessment Of Nanomaterials in cosmetics

This publication gives current guidance on how to evaluate the safety of nanoparticles used in cosmetic goods. It covers the key components of safety evaluation, including basic consideration, material characterisation, assessment of exposure hazards identification or dose response characterisation and risk assessment.

A cosmetic product's safety should be assessed based on examining the physicochemical qualities along with pertinent toxicological endpoints of each constituent in relation to the anticipated exposure from the completed product's intended usage. If a manufacturer wishes to use a nanoparticles in a cosmetic product, whether it is a novel substance or a modified form of an ingredient that has been already commercialised, this information suggests that the manufacturer meet with the FDA to talk about the test procedures and the information required to verify the product's safety, including short term and long term toxicity data, as needed.

8.MARKET GROWTH

Infinium worldwide research has recently published a research on the market for nanotechnology in cosmetics that offers a detailed analysis of the market's segments and subsegments on a worldwide and regional level. The study also shows on the short-and long-term impacts of macroeconomic variables, drivers , and regional market for nanotechnology in cosmetics. The report predicts that during the projected period of 2022 to 2028, the global market for the nanotechnology in cosmetics will expand at a considerable CAGR.

The newest and fastest-evolving technology currently available is the inclusion of nanotechnology in cosmetic composition. Nanotechnologies' benefits for the cosmetics business include UV protection, deeper skin penetration, and enhanced hydration. Furthermore, the market's expansion will be significantly impacted by young people's growing use of high-quality cosmetic products. In order to improve the performance of cosmetics, nanotechnology is used in a variety of ways, including regulating drug release, improving physical stability, increasing the effectiveness of the active ingredient's skin penetration and entrapment, and strengthening moisturizing power. The extensive usage of nanotechnology in the cosmetics sector has boosted growth over the anticipated period.

The use of the micelles nanoparticles in the creation of cosmetic items will provide the market with attractive growth prospects throughout the forecast period.

Fig 8.1Global market study of nanocosmaceuticals

(Ref:www.infiniumglobalresearch.com)

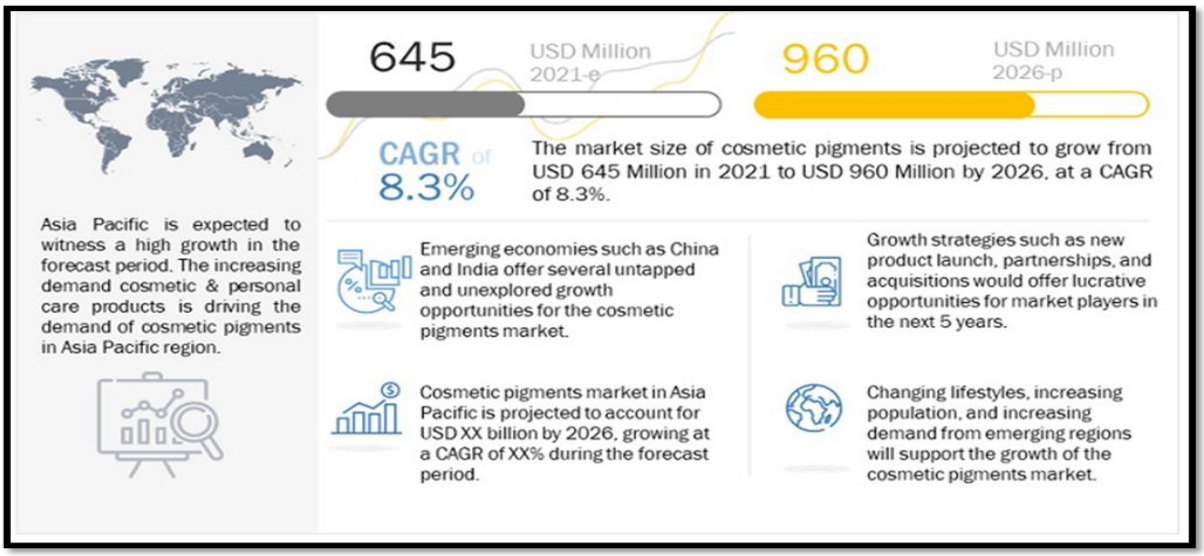


Fig. 8.2 Market study of nanocosmaceuticals

Ref: www.marketsandmarkets.com

9.CONCLUSION

In conclusion, nanotechnology has transformed the cosmetics sector by bringing a host of advantages, including better skin penetration, controlled release of active ingredients, greater formulation stability, and enhanced sensory characteristics. Liposomes, solid lipid nanoparticles, and nanoemulsions are just a few examples of the many uses for which nanoparticles are employed in cosmetics, such as sun protection, anti-aging, and skin lightening.

The creation of multifunctional nanocarriers, the use of organic substances in the synthesis of nanoparticles, and the use of nanotechnology in individualised skincare products are the current trends in nanotechnology for cosmetics. Additionally, eco-friendly and sustainable cosmetics based on nanotechnology are gaining popularity.

Future developments in nanotechnology for cosmetics could include the development of intelligent nanocarriers for on-demand release of active ingredients, the use of sophisticated imaging techniques for precise targeting of active ingredients to particular skin layers, and the fusion of nanotechnology with other cutting-edge technologies like artificial intelligence and biotechnology.

However, concerns about the safety of cosmetics made with nanotechnology persist, and further study is required to weigh the possible advantages and hazards of these products.In order to ensure proper safety evaluations are carried out before releasing these goods into the market, it is crucial to regulate the use of nanotechnology in cosmetics.

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