Nanotechnology In Cosmetology: A Review

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Abstract— Nanotechnology is the combined field of chemistry, biology, engineering, electronics and material sciences .Hence, it is applied for manufacturing of biotechnology, materials, medical diagnosis and treatment, textile, space exploration, etc. In cosmetic field, application of nanotechnology has been introduced since 1961. Widely used nanomaterials in cosmetic are: liposome, polysome, noisome, nanoemulsions, gold nanoparticles, etc. Majorly, nanomaterials are used in hair care products like hair shine serums, conditioners and in skin care products like anti-wrinkle creams, anti-aging creams. The cosmetic industry was the first to implement nanotechnological principles in the product formulation. More than one thousand registered nanotechnology based products on global market in 2009, but more than 13% were classified as cosmetic product use. To overcome the drawbacks regarding the traditional products, use of nanotechnology is escalating in the area of cosmeceuticals. Hence cosmeceuticals are regarded as the fastest growing sector of the personal care industry. As nanotechnology finds new formulations, new applications and use of nanoparticulate structures in the production of cosmetics or cosmeceuticals. The use of nanomaterials is on increase due to great functions.

Index Terms— Nanotechnology, Liposomes, Nanoparticles, Cosmetics.

I. INTRODUCTION

It is a combined field of Chemistry, Physics, Electronics, Biology, Materials science and Engineering. Nanotechnology is the fastest growing area for the maintenance of skin health as well as for management of cutaneous diseases. In actuality, the science of very small things is nanotechnology. Nanoparticles, i.e., particle sized between 1nm to 100nm, can have significantly differ properties than the same materials at larger forms because they have relatively larger surface area to mass ratio, therefore more atoms may come into contact at the surface. Nanotechnology is applied for manufacturing of materials, electronic chips, for medical diagnosis and healthcare, biotechnology, space exploration, textiles, sports equipment, etc. Also it has been entered in the field of cosmetics for instance; dermal preparations and other health products with moisturizing creams prepared by using liposomes nearly existed 40 years ago. Many cosmetic formulations incorporate special nanoparticles that may be coated or may not be coated, provides sunscreen, tactile, light scattering and matte effects for the wearer. Cosmecuticals products are not entirely pharmaceutical or personal care product, they are somewhere in the middle of two. Such products shows therapeutic efficacy on the skin. Also they can be used in various categories like skin products, hair care products, make-up products, body care products and many more. Their use have been diversified for the treatment of various conditions like hair dandruff, wrinkles, aging, dryness of skin and hair, dark spots, uneven complexion, acne and acne marks etc. 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. They are used in hair care preparations, such as in treatment of hair loss and to prevent hair from turning grey such as Identik Masque Floral Repair, Origem hair recycling shampoo, and Nirvel hair-loss control shampoo. Nanocosmeceuticals make the fragrances last longer, for example, Allure Parfum and Allure Eau Parfum spray by Chanel. These make the skin care formulations more effective and increase the efficacy of sunscreens by improving UV protection in them. 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. The cosmetic industry has now started using nano-scale ingredients quite routinely. Some of the anticipated benefits that can be expected from these tiny ingredients are better entrapment, better dispersibility, enhanced performance, improved textural quality, protection of sensitive and volatile actives, and better penetration. Another added advantage is that these products look upmarket, elite, and trendy at the same time.

Nanoparticles exhibit better dispersion of colour and improved texture

II. TYPES OF NANOMATERIALS IN COSMETICS:

1. Liposomes:

Liposomes are most widely used for the cosmeceutical preparations. They are the vesicular structures having an aqueous core which are enclosed by a hydrophobic lipid bilayer. The main component of liposome lipid bilayer is phospholipids; these are GRAS (generally recognized as safe) ingredients, therefore minimizing the risk for adverse effects. To protect the drug from metabolic degradation, liposome encapsulates the drug and releases active ingredients in a controlled manner. Liposomes are suitable for delivery of both hydrophobic as well as hydrophilic compounds. Their size varies from 20nm to several micrometers and can have either multilamellar or unilamellar structure. The first liposomal cosmetic product to appear on the market was the anti-ageing cream 'Capture' launched by Dior in 1986. Phosphatidylcholine, one of the main ingredients of liposomes, has been widely used in skin care products and shampoos due to its softening and conditioning properties. Liposomes have been formed that facilitate the continuous supply of agents into the cells over a sustained period of time, making them an ideal candidate for the delivery of vitamins and other molecules to regenerate the epidermis. They have also been used in the treatment of hair loss. Minoxidil, a vasodilator, is in the active ingredient in products like Regaine that claim to prevent or slow hair loss. The skin care preparations with empty or moisture loaded liposome reduce the transdermal water loss and are suitable for the treatment of dry skin. They also enhance the supply of lipids and water to stratum corneum. Some of the liposomal cosmetic formulations currently available in the market.

2. Nanoemulsion:

These are transparent metastable dispersions with droplets of one liquid within another and possessing unique tactile and textural properties. Their structure can be manipulated based on the method of preparation to give products with distinct characteristics, for example, water-like fluids or gels. Nanoemulsions possess distinct advantages over large-scale emulsions. They are transparent or translucent systems and have a larger surface area owing to reduced dimensions. Researchers have

already established that the smaller the size of the oil globule in an emulsion, the higher the stability and the better is the suitability to load active ingredients. It is therefore necessary to understand the various processes of nanoemulsification. While formulating and characterizing nanoemulsions, concluded that homogenization is the most favored method to achieve the desired size of nanoemulsion droplet. The components of nanoemulsions are generally GRAS ingredients which can break down to safe components and are therefore considered as relatively safe systems. A popular cosmetic item, Korre's Red Vine Hair sunscreen, makes use of these nanoemulsions.

3. Dendrimers:

Dendrimers possess a spherical architecture composed of a core from which symmetric units are built, and this structure is the main reason for the versatility of dendrimers. Dendrimers are polymers, and due to their stability they help in delivering ingredients through the skin. Dendrimers are used in shampoos, and deodorants. The surface activity of dendrimers' symmetrical branches is due to the hydrophobic properties of their edge part combined with the hydrophilic characteristics of the core. Properties such as monodispersity, polyvalence, and stability make them ideal carriers for drug delivery. Dendrimer structure has helped to increase the overall loading and skin penetration of resveratrol (known for its anti-oxidant and anti-aging properties), which has led to the later scale-up and commercialization of this dendrimer structure-based product.

4. Inorganic:

Inorganic nanoparticles are non-toxic, hydrophilic, biocompatible, and highly stable compared to organic nanoparticles. Their major difference—apart from the aforementioned—is that inorganic nanoparticles are synthesized from inorganic elements (Ag, Au, Ti, etc.), while the organic ones are synthesized from polymers. One of the most widely used inorganic nanoparticles for sunscreens is TiO2, and in nanoscale it has a higher sun protection factor (SPF) which makes it more efficient, and has a better cosmetic result due to its transparency, compared to TiO2 pigment. Oftentimes, in the market, companies use words such as "sheer" or "invisible" when nanoscale TiO2 or ZnO are used. It is reported that nanoscale TiO2 and ZnO show great advantages over many products at larger than nano-dimensions. Micro-TiO2 and ZnO are used as ingredients in sunscreens due to their UVA and UVB absorption capabilities. Nanoparticles of ZnO and TiO2 are also widely used in sunscreens as UV filters starting at the size of 20 nm. They show better dispersion and leave a better cosmetic result. For the analysis of ZnO and TiO2 in cosmetic products, the combination of Transmission Electron Microscopy (TEM) and X-ray Powder Diffraction (XRD) is considered an efficient approach. Regarding their safety, inhalation of high concentrations of ZnO nanoparticles has been reported to cause health damage. However, a different route of exposure (i.e., the dermal route), for ZnO concentrations in typical sunscreen formulas, are considered safe since there is neither proof for penetration into the viable epidermis nor toxicity issues.

5. Gold and Silver Nanomaterials:

Nanogold or gold nanoparticles exhibit various sizes ranging from 5nm to 400nm. Interparticle interactions and assembly of gold nanoparticles play an important role in determination of their properties. They exhibit different shapes such as nanosphere, nanoshell, nanocluster, nanorod, nanostar, nanocube, branched, and nanotriangles. Shape, size, dielectric properties, and environmental conditions of gold nanoparticles strongly affect the resonance frequency. The color of nanogold ranges from red to purple, to blue and almost black due to aggregation. Gold nanoparticles are inert in nature, highly stable, biocompatible, and noncytotoxic in nature. Nanogold is very stable in liquid or dried form and is nonbleaching after staining on membranes; they are also available in conjugated and unconjugated form. They have high drug-loading capacity and can easily travel into the target cell due to their small size and large surface area, shape, and crystallinity. Gold nanoparticles have been studied as a valuable material in cosmeceutical industries due to their strong antifungal and antibacterial properties. These nanoparticles are used in variety of cosmeceuticals products like cream, lotion, face pack, deodorant, antiaging creams, and so forth. Cosmetic giant companies like L'Oreal and L'Core Paris are using gold nanoparticles for manufacturing more effective creams and lotions. Main properties of nanogold in beauty care consist of assets, namely, acceleration of blood circulation, anti-inflammatory

property, antiseptic properties, improvising firmness and elasticity of skin, delaying aging process, and vitalizing skin metabolism.

6. Solid Lipid nanoparticles and Nanostructured lipid carrier:

Solid lipid NPs (SLNs) and nanostructured lipid carriers (NLCs)have an inner lipid core which is solid at body temperature, and are commonly prepared by microemulsion and high-pressure homogenization. In SLNs, the lipid mixture is formed only by solid lipids (e.g., long-chain glycerides, fatty acids, waxes), while in NLCs the hydrophobic matrix is made up of a combination of solid and liquid lipids (e.g., short-chain glycerides) in a ratio ranging between 70:30 and 99.9:0.1. This class of non-vesicular NPs is mainly investigated for their potential as carriers of chemically labile molecules and for their occlusive properties, which promote skin hydration and the penetration of bioactive agents. NLCs are considered to be an upgrade from SLNs; indeed, the inclusion of oils in the lipid matrix decreases its crystallinity, improving the loading capacity and long-term encapsulation stability of the system.

7. Niosome:

Niosomes are vesicles composed of nonionic surfactants. The niosomes have been mainly studied because of their advantages compared with the liposomes: higher chemically stability of surfactant than phospholipid, require no special conditions for preparation and storage, they have no purity problems and the manufacturing costs are low. The advantages of using niosomes in cosmetic and skin care applications include their ability to increase the stability of entrapped drugs, improved bioavailability of poorly absorbed ingredients and enhanced skin penetration.

8. Cubosome:

Cubosomes are the advanced nanostructured particles which are discrete, submicron, and self-assembled liquid crystalline particles of surfactants with proper ratio of water that provides unique properties. Cubosomes are formed by self-assembled structures of aqueous lipid and surfactant systems when mixed with water and micro structure at a certain ratio. Cubosomes are bicontinuous cubic liquid phase, which encloses two separate regions of water being divided by surfactant controlled bilayers and wrapped into a three dimension, periodic, and minimal surface, forming a strongly packed structure. They consist of honeycombed (cavernous) structure and they appear like dots which are slightly spherical in structure. They exhibit size range from 10 to 500 nm in diameter. They have ability to encapsulate hydrophilic, hydrophobic, and amphiphilic substances. Cubosomes have relatively simple preparation methods; they render bioactive agents with controlled and targeted release, possess lipid biodegradability, and have high internal surface area with different drug loading modalities.

9. Nanocrystal:

Nanocrystals are crystals having size less than 1µm. They are aggregates comprising several hundred to tens of thousands of atoms that combine into a "cluster". Typical sizes of these aggregates are between 10-400 nm. Nanocrystals of poorly soluble drugs can also be incorporated in cosmetic products where they provide high penetration power through dermal application. The first cosmetic products appeared on the market recently; Juvena in 2007 (rutin) and La Prairie in 2008 (hesperidin). Rutin and hesperidin are two, poorly soluble, plant glycoside antioxidants that could not previously be used dermally. Once formulated as nanocrystals, they became dermally available as measured by antioxidant effect. The nanocrystals can be added to any cosmetic topical formulation, e.g. creams, lotions and liposomal dispersions.

10. Nanocapsule:

These are based on encapsulation technology and can carry drug payloads for local action or targeted drug delivery. Depending on the nature of material to be incorporated, different types of nanocapsules are formulated (Tadros, 1992). Companies like Exlica Ltd. and MiCapt are exploring various materials to be utilized as nanocapsule shells, for example, polymer microbeads, silica nanoshells, microbial cell walls.

- Major classes in Nanocosmecuticals:

Classes	Cosmetics Products
Skin	Sunscreen cream, Antiaging cream.
Hair	Shampoo, Conditioner, Hair color and Dye, Hair serum.

Nail	Nail Paint.
Lip	Lipstick, Lip balm, Lip gloss.
Dental	Toothpaste, Soap, Toothbrush.

1. Skin:

Cosmeceuticals for skin care products ameliorate the skin texture and functioning by stimulating the growth of collagen by combating harmful effect of free radicals. They make the skin healthier by maintaining the structure of keratin in good condition. In sunscreen products zinc oxide and titanium dioxide nanoparticles are most effective minerals which protect the skin by penetrating into the deep layers of skin and make the product less greasy, less smelly, and transparent. SLNs, nanoemulsions, liposomes,and niosomes are extensively used in moisturizing formulations as they form thin film of humectants and retain moisture for prolonged span. Marketed antiaging nanocosmeceutical products assimilating nanocapsules, liposomes, nanosomes, and nanospheres manifest benefits such as collagen renewal, skin rejuvenation, and firming and lifting the skin.

2. Hair:

Nanocosmetic hair products include shampoos, conditioners, hair colors and dyes, hair serums and various hair styling products. Nanoparticles are majorly used in shampoos, and they help in retaining the moisture in the hair by regulating the contact time of the moisturizing agent with the cuticles of the hair and forming a layer over it. This layer protects the hair follicles and cuticles from damage and dryness. Another product where this technology is used is in the making of the hair conditioners. It is found that the use of nanoparticles impart these products with properties of softening, shine inducing and enabling them for detangling of hair. The carries from this new technology like niosomes, nanoemulsion, nanospheres, and liposomes etc. also perform restorative and protective finctions for the cuticles of the hair and impart healthy shine in the hair.

3. Nail:

Nano-based cosmeceuticals are being developed for nail care. Nail paints based on nanoparticles improve the toughness and resistance of the nails. They have many advantages like drying to a very hard state, resisting chipping, cracking and scratching. It can also be used for therapeutic purpose to treat onychomycosis.

4. Lip:

Lip care products in nanocosmeceuticals comprise lipstick, lip balm, lip gloss, and lip volumizer. Variety of nanoparticles can be coalesced into lip gloss and lipstick to soften the lips by impeding transepidermal water loss and also prevent the pigments to migrate from the lips and maintain color for longer period of time. Lip volumizer containing liposomes increases lip volume, hydrates and outlines the lip, and fills wrinkles in the lip contour.

5. Dental:

By using nanotechnology in toothpastes it is very helpful for preventing damage to the tooth enamel. Hydroxyapatite is a key component of tooth enamel as nano crystals. It is also the main component of bone and teeth. The nano form of hydroxyapatite is used in toothpaste that forms a protective film around tooth enamel and even restores the surface in damaged areas and it also reduces the pain. This is the world's first reminerilizing toothpaste.

Risk Factor of Nanotechonolgy in Cosmetic:

a) Nanoparticles have been found to cause a large number of risks both to humans as well as to the environment.
b) The toxicity of nanomaterials is affected by their properties which are attributed to their.
c) Smaller size
d) Chemical composition
e) Surface structure
f) Solubility
g) Shape

Routes of Exposure:

- Inhalation:

From products containing nanomaterials, such as spray versions of sunscreens containing nanoscale TiO2.

- Ingestion:

Due to unintentional/intentional hand-to-mouth transfer of nanomaterials from products containing them. E.g. lipsticks.

- Through Skin:

Studies by the US Government Accountability Office have raised concerns that nanomaterials in sunscreens could penetrate damaged skin.

- Safety Assessment:

Nanomaterials in cosmetics could have various functions (e.g., UVA and UVB filters in sunscreens, nano-preservatives). The unique characteristics of any given nanomaterial which may lead to the desired function/property of the cosmetic product may also pose a risk to the consumer. With this in mind, a standard safety evaluation of all nanomaterial is necessary, including tests dealing with the nano-characteristics (e.g., penetration into viable skin layers due to their small size as well as inhalation experiments in the case of sprays/powders). For FDA, some of the key points that should be included in the safety assessment according to the recent guidance are the physicochemical characteristics, agglomeration, and size distribution of NMs, morphology, solubility, density, porosity, stability, and impurities. In addition, the potential exposure routes of NMs should be identified, and in vitro and in vivo toxicological data—including studies on dermal penetration and potential inhalation, genotoxicity studies, and possible skin and eye irritation studies—should be conducted. The exposure assessment for NMs follows a similar procedure to non-NM ingredients, but with a special focus on the nano-aspects. The schematic outline of the safety assessment of a cosmetic product containing NMs is presented. In Europe, there are NMs for which the SCCS has expressed inconclusive opinions, e.g., Colloidal Silver (nano), Styrene/Acrylates copolymer (nano) and Sodium styrene/Acrylates copolymer (nano), and Silica, Hydrated Silica, and Silica Surface Modified with Alkyl Silylates (nanoform), which is why the EC requested that the SCCS to should assess if a potential risk can be identified. The in conclusiveness is due to the lack of data submitted by the Applicants.

CONCLUSION

From this paper it can be concluded that use of nanotechnology in cosmetics has led to quality enhancement of products. It has proved useful in enhancing various properties of products like efficacy, shelf life and performance. In cosmetics widely used nano materials are: nanosphere, nanoemulsions, noisome, polysomes, gold nanoparticle, liposome, dendrimers etc. The use of nanoparticles also enhances the physical stability of the product thereby also increasing the shelf life. They also help in active transport of active ingredients to the specific target site. The major area where nano material are used are skin care products like anti-aging, anti-wrinkle creams, hair care products like hair conditioners and shine serums, perfumes are also made using this technology which enables long lasting effect in perfumes. Many make up products are also made with the help of the nano technology. Although nano materials provide many advantages in making cosmetics but these nano materials can also have disadvantages. The most common disadvantage of these is the probable toxicity that they can induce in the product. Therefore more extensive research is required in this field so that clear understanding of usefulness of nanotechnology in cosmetics can be made.

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