

Nanotechnology and Its Application in Cosmetic Industry A Concise Review

Keerthi S Iyer

Student: Dept. Mechanical Engineering
BVDU College of Engineering,
Pune, India
keerthivendormadom@gmail.com

Sachin S Chavan

Prof: Dept. Mechanical Engineering
BVDU College of Engineering,
Pune, India
sschavan@bvucoep.edu.in

Abstract:-Nanotechnology, the field of science which deals with particles of size 10^{-9} m is seen to find application in all fields like medicine, textile, electronic to industries like cosmetics. The enhanced physiochemical properties of nanomaterials make them interested in skin and hair care products which reflects in better UV filtering, anti-tanning, anti-aging like properties. The materials used in these cosmetic products their properties; characterization technique and the clinical testing are discussed in this review article.

Keywords:-Nanomaterials; Titanium Dioxide; Clinical Testing; Safety Assessment .

I. INTRODUCTION

Nanotechnology is one of the fields of engineering which deals with designing or manipulation of materials and devices with at least one dimension in the size of 1 nm-100 nm (10^{-9} m). In simpler words one billionth of a meter is one nanometer. Nanotechnology has been of greater interest for scientists for over a couple of decades due to their effective bridging of bulk material properties to their macroscopic and atomic counter parts. The physical, chemical and biological properties when employed results in enhanced properties of materials which are found to be more pragmatic than their corresponding bulk part and thus, nanotechnology has become a part of all fields of science. In 1959 the great physicist Richard P. Feynman visualized nanotechnology for the first time and he was honored with Nobel Prize in the field for the same. But it was K. Eric Drexler in 1980s did introduce the word Nanotechnology and he meant it for the construction and development of machines in the smallest scale like the size of a molecule which are a few nanometers wide [1].

The synthesis and fabrication of nanomaterial which includes the supramolecular chemistry, self-assemble and replication techniques, sintering of nanostructured metallic alloys, use of quantum effects and creation of sensors using various templates like biological templates, films and surface modification^[3] under various controlled conditions reflects in appreciative characteristics of their basic properties such as electrical conductivity, thermal properties, solubility, surface to volume ratio...etc. Nanomaterial of different size and shapes ranging from 0D to 3D are made into fibers, wires, plates, rods

and powder depending on its application in diverse field like Medicine, Textile, Electronic, Aerospace, Energy production, consumer and cosmetic industries.

Nanotechnology is considered to create a new industrial revolution in the coming years. Private sector, public sector, government bodies and educational institutions are spending a lot in Nanotechnology research. One such industry is the cosmetic industry. Cosmetics industry, one of the most emerged and enthralling industry in consumer sector have emerged to be holding an increased growth potential in the global economy. Products that make skin look healthier, smoother and younger are the basic of a cosmetic industry, which are in search of materials which will contribute to the above mentioned necessity. Cosmetic products includes face creams, talcum powders, soaps, hair shampoos and conditioners, body lotions, shaving foams, lip balms and makeup products like skin foundations, lipsticks, eye shadows..etc. However, any material cannot be used without studying their side effects and for the same there are official bodies which tests the ingredients, quality and doses to ensure the safety in using the products for people of different ages and gender.

Materials used in cosmetic products should be ensured that the creams or powders used for necessities like UV protection or anti-aging are easy to penetrate skin, should overcome the insolubility problem and protection of physical and chemical decomposition over a period of time. Human skin is made of 3 different layers: epidermis, dermis and hypodermis. Nails, hair, sebaceous, apocrine and eccrine sweat glands are other constituents of human skin. The thickness of the layers of skin defers with body parts, age and gender. Skin plays a major role in protecting human body from exterior environment like, preventing the penetration of UV rays and other toxic substance present in the air, prevents loss of vital body fluids from going out the body and at the same time expels toxic substance from the body though sweat, provides mechanical support, helps in balancing body temperature and helps in vitamin D synthesis when in presence of sunlight. Therefore it is very important to take better care of skin compared to any other body part and if not taken proper care of skin it results in early ageing, wrinkles, skin darkening, and sometimes even in skin cancer [8].

Studies reveals that all major cosmetic manufactures are using various nanomaterials in their products and the products are already playing major role in the market. Nanomaterials are getting such attention in cosmetic products is due to their size, stability, water solubility, crystallite size, photocatalytic activity, redox potential, porosity and surface to volume ratio, which are easy to be absorbed into the skin [9]. By stability we mean the nanoparticles which are encapsulated by unsaturated fatty acids, vitamins or antioxidants which are base of any creams or lotions do not decay very easily. As our skin pores are very small, particles of nanometer size enters the skin very easily which also creates a passage for vitamins and minerals. It is found that nanoparticles are very good UV filters on the skin and are much better than any products which already existed in the market. Literature shows that there a many nonmaterial which are already used in cosmetic goods and in this review article we will discuss some of the very generally used materials.

II. NANOMATERIALS IN COSMETICS

Titanium dioxide and zinc oxide which has the ability to reflect or scatter UV radiation have been a major component in sunscreens. These are opaque and white in nature when in their bulk form which results in the cream being noticeable when applied on skin. This has been remedied by the use of titanium dioxide and zinc oxide in nanometer scale. These are clear and translucent on the skin which reflects on attractive skin [14].

Nanosilver which have a very good antimicrobial acts as preservative agents in cosmetics products. A silver nanoparticle which gets attached to the surface and penetrates a microorganism alters the cell functions of it and inhibits its growth. This property of silver nanoparticle has been applied in biomedical, pharmaceutical and cosmetic industry. Nanosilver is also known for its wound healing property with minimal scaring. This property contributes to use of silver nanoparticles in scar removal creams [16]. Underarm deodorants are manufactured with silver nanoparticles in it which enhances the ability of the deodarants to perform its function around the day. And nanogold is utilized in toothpastes which makes the paste more disinfective [19].

Liposomes which are composed of phospholipid and cholesterol bilayer are spherical in shape which makes them carries to deliver drugs on targets. There are considered to be one of the effective dermal drug carriers. The lipid bilayer of the liposome merges with the cell membrane and delivers its contents at the target. Liposomes as drug carriers are used to cure acne, hyperpigmentation, melasma, alopecia, psoriasis, hirsutism, cellulites and to increase the occlusive effect (hydration of skin), UV protection and antioxidant property [20].

Emulsions droplets which have a diameter between 100 and 500 nm and are oil-in-water mixtures are known as nanoemulsions. They are much higher surface which makes them efficient in foams, creams, lotions and sprays as they avoid sedimentation, flocculation, coalescence..etc which some very common problems faced by cosmetic products.

These are considered to be least toxic and are therefore formulated as surfactants in beauty products [21].

Atoms when aggregate combining thousands of atoms form nanocrystals which have size between 10 to 400 nm. These nanocrystals exhibits enhanced physiochemical properties than their macroscopic molecule. These can be administrated orally and at the same time can penetrate skin easily and therefore they are used in anti-ageing and skin protective products [22, 23].

Solid lipid nanoparticle is another commonly administrated nanomaterial in cosmetic products. As the name suggests these are solid substances stabilized by surfactants under the influence of body temperature but are basically made up of oil droplets of lipids. These are also used as drug carriers due to their novel properties like resistance to chemical degradation, controlled release of drugs embodied in it, UV blocking property and their ability to increase water holding capacity [24].

Other such nanocarriers are cubosomes, nanocapsules, niosomes and transfersomes which are getting more attention these days in cosmetic and pharmaceutical industry due to their ability to carry drugs and deliver them at specified locations. Cubosomes are made up of self-assembled liquid crystalline structures such as bicontinuous cubic liquid crystalline phase surfactants [25]. They are of greater interest due to their properties like large surface area, low viscosity, their ability to stay stable at any dilution state, higher heat stability and their capacity to carry both hydrophilic and hydrophobic substances [26]. Nanocapsules are small packets made of a polymer which surrounds a solid or liquid material which are the drugs to be delivered at specified point of interest and are good UV filters [26]. Niosomes which are similar to liposomes are made up of surfactants and cholesterol is more stable as a carrier with higher permeation capacity [27] whereas transfersomes are similar lipid vesicles with more flexibility and an aqueous core [28].

III. NANOMATERIAL TESTING FOR SAFTEY ASSESMENT

Nanomaterial designed for particular application cannot be used as they are. They undergo critical testing and are included in a product in prescribed dosages only. Nanomaterials when consumed more than the critical limits could be hazardous to health; therefore it is mandatory that they are approved by government bodies before including them in any consumer product. The very basic characterizations are conducted to study the physical properties like size and shape of the particle, size distribution, surface morphology, crystal structure, and to evaluate chemical properties like stability, composition, molecular and structural morphology, surface chemistry...etc. Some of the very common instruments for the above mentioned analysis are UV/Visible spectroscopy, IR spectroscopy, Raman spectroscopy, particle size analyzer, photoluminescence spectroscopy, X-ray diffraction (XRD), Transmission electron microscopy (TEM), Scanning electron microscopy (SEM), atomic force microscopy (AFM), Energy

dispersive X-ray Spectroscopy (EDAX), Laser scanning confocal microscopy (LSCM) and Particle induced X-ray emission (PIXE). Some of the characterization techniques which are very particularly used in analysis of nanomaterials incorporated in cosmetic products and the property observed in each technique is tableted in Table 1.

Sr. No	Table Column Head	
	Characterization technique	Properties Investigated
1	Scanning electron microscope (SEM)	Shape and morphology
2	Energy dispersive X-ray diffraction (EDAX)	Elemental information of individual particles
3	Power X-ray diffraction(XRD)	Crystallinity /morphology and size
4	Disc centrifugation or Lased diffraction techniques	Particle size distribution
5	Cryo-SEM	Imaging
6	Dynamic light scattering (DLS)	Measure size of dispersed liposomes
7	High performance liquid chromatography (HPLC) / Ultra performance liquid chromatography (UPLC)	Test to quantify the levels of active present
8	Sensitive Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES)	To determine trace metals and to measure the quantity of nanomaterial
9	Inductively Coupled Plasma-Mass spectroscopy (ICP-MS)	To determine trace metals and to measure the quantity of nanomaterial

Table 1: Some of the Commonly Used Characterization Techniques in Cosmetics ^[18]

Nanomaterials are not limited to these tests. The materials undergo testing depending on its required performance in a product. Once the nanomaterials synthesized meet the basic necessity they are then administrated into products in a laboratory. These products are at first modeled mathematically and simulated with the help of software. The developed products are then clinically tested. Some of the clinical tests are listed below ^[19]:

- Phototoxicity testing via the 3T3 NRPT
- Dermal absorption measurements on human/pig skin
- In vitro micronucleus test
- In vitro mammalian chromosome aberration test
- Skin irritation testing via Episkin
- Skin corrosion testing via transcutaneous electrical resistance (TER)
- Genotoxicity
- Mutagenicity test
- Embryotoxicity testing via embryonal stem cell test, micromass assay, whole embryo culture
- In vitro mammalian cell gene mutation test

These tests are important since any cosmetic products should meet the requirements like the ability of the nanomaterials to penetrate through the skin in presence of physiological barriers, how much cell damage the product may cause upon interaction with cell and its ability to create mutagenicity and genotoxicity in skin. Food and Drug Administration (FDA) and United States Environmental Protection Agency (USEPA) in the USA and Health and Consumer Protection Directorate of the European Commission are few scientific bodies whose approval is mandatory to release a product into the market [19].

IV. CONCLUSION

Nanotechnology is one of the blooming developments of science which has found its application in all most all fields of science. Today thousands of products are already present in the market which contains materials of at least one of its dimension in nanometer scale. Cosmetic industry which always is in search of new and advanced materials to enhance their product quality, so that they can meet a consumer's need, has found had nano-scale fabricated materials of great interest. Nanomaterials which are small can easily penetrate skin and are fabricated such that they can release drugs at targeted locations. This property of nanomaterials can enhance the UV filtering and scar healing capacity of the already existing products. All major manufactures of cosmetic products had already released products in the market which contains at least one nanomaterial. Administrating nanomaterials in consumer products needs to be approved by agencies which tests the safety of the products when used by humans. Studies made across the word in nanotechnology is getting more and more advanced, it is estimated that in couple of decades nanotechnology will take over the entire consumer industry.

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