Nanotechnology in Cosmetics

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Date of Submission: 19th July, 2014 Date of Acceptance: 27th August, 2014

Abstract

Today nanotechnology is associated with almost every sector, from molecular biology to electronics or from textiles to food and beyond. In the cosmetics sector, this new trend has been extremely used by cosmetics manufacturers to improve their existing products and also to develop new ones. They use nanomaterials to provide better UV protection, deeper skin penetration, longer-lasting effects, increased color and finish quality etc. Inorganic nanoparticles like TiO2 and ZnO are used as UV filters in sunscreens. Except these, different types of encapsulation and delivery systems such as liposomes, niosomes, dendrimers, nanoemulsions, or solid lipid nanoparticles etc. are also used in cosmetics and personal care products. This review article provides some information about the types of nanomaterials used in the cosmetic products and also about the potential benefits and risks associated with their use.

Keywords: Nanotechnology, Cosmetics, Novel delivery systems, TiO2, ZnO, Health risks

1. Introduction

Nanotechnology is a combined field of chemistry, physics, electronics, biology, materials science and engineering i.e. it is an interdisciplinary subject. Thus if all these scientific disciplines are converging, a lot of numbers of potential application may be obtained, which includes everything from tennis rackets to medicines to entirely new energy systems. Actually nanotechnology is the science and technology of very small things. A nanometre is one billionth (10^{-9}) of a metre, which is very small, about 80,000 times smaller than the width of a hair. Nanoparticles (Particles sized between 1nm and 100nm) can have significantly different properties than the same materials at larger form because it has relatively larger surface area to mass ratio, therefore more atoms may come into contact at the surface i.e. they become more chemically reactive than the bulk materials[1,2]. Nanoscale materials have been used for decades and have different applications, like they are used for making window glass, sunglasses and paints. Now, it is applied for manufacturing of materials, electronic chips, for medical diagnosis and health care, energy, biotechnology, space exploration, security, textiles, sports equipments etc. Progress of nanotechnology will also give opportunities for cosmetic industry to develop new biocompatible and biodegradable therapeutics, delivery systems and more active compounds. Now-a-days, a greater number of people (women along

with an increasing number of males) are using cosmetics to enhance the beauty of their body. Therefore, cosmetic manufactures have been tried to produces a number of more attracting modern cosmetic related products, which contains nano-sized components because nanoparticles would helps to provide better performance and better finish quality of the products.

2. Nanomaterials used in cosmetics

Currently, nanoparticles are mainly used for UV filters and also for agent delivery. Actually the function of delivery system is to supply appropriate concentration of the active ingredients to appropriate site in the body for the correct period of time[3] and for that reason different novel delivery systems have been widely used in cosmetic products which are discussed briefly in the following.

Inorganic Nanomaterials used in cosmetics

Nanosized TiO_2 and ZnO have been used in sun care products since the early 1990s[4]. For sunscreens, these inorganic nanoparticles provide several advantages. Use of traditional chemicals for UV protection suffer from its poor long-term stability but these nano TiO_2 and ZnO provide longer protection from UV-A and UV-B radiation compared with other sun-screen agents. Other fact is that nanoscale TiO_2 and ZnO minimize the undesirable white color and sticky feel of the materials with the decrease of their particle size which is very important because most of the customer prefers cosmetics product that are translucent and non sticky. Other nanoparticles, such as nano gold has been used in an 'energizing' moisturizer cream and also in facial mask[5] and some personal care products uses nano silver because of its anti-bacterial properties[6,7].

Other nanoscale materials used in cosmetics

Vesicular delivery systems: When these vesicles are applied on skin, they might act as a carrier to deliver entrapped molecules to the right site (but tend to remain in the upper layers of the stratum corneum) for sustained release of active compounds[8-10]. They enhance the skin tolerance of ingredients, such as unsaturated fatty acids, vitamins or anti-oxidants. The examples of these types of delivery systems are following:

Liposomes: Liposome has a colloidal vesicular structure. It contains an internal aqueous volume that is surrounded by concentric layers of phospholipids which are GRAS (generally regarded as safe) products. Both hydrophilic and hydrophobic drug can be incorporated in it, water soluble drug may be trapped in aqueous core and fat soluble drug in phospholipids. The lipid bilayer of liposomes can fuse with other bilayers such as the cell membrane and helps to ease release of its contents that makes them useful for cosmetic delivery applications. One of the reasons for the widespread use of liposomes in the cosmetic industry is their ease of preparation and the ability to improve the absorption of active ingredients by skin. They are

used in sunscreen cream, antiaging cream and also in moisturizing cream[11-13]. Liposomes have also been used in the treatment of hair loss[14].

Phytosome: They are used in sun-care product to protect the sun-exposed skin by releasing a photo reactivating enzyme obtained from a marine plant, Anacystinidulans[15].

Transferosomes: They are more elastic than liposomes and have greater efficiency[16]. It is used in anti wrinkle cream.

Ultrasome is also used in anti wrinkle cream. It helps to prevent the damage of collagen and elastin production[17.18].

Ethosomes are soft, malleable vesicles used for enhanced delivery of active agents[19].

Nanosome and Fullersomes, both of these are used in skin cream for different purposes, former is used to upgrade skin to a healthy and younger looking feature[20] and the later is used to refresh dark circles under the eyes[21].

Niosomes: These are non-ionic surfactant vesicles. They are vesicular systems and can be used as carriers of amphiphilic and lipophilic drugs[22].

Except vesicular delivery systems other types of delivery systems that are used in cosmetic products are:

Nanoemulsions: Nanoemulsions are basically oil-in-water dispersions. The droplet diameter of this is generally smaller than 100 nm. They are used for increasing the content of nourishing oil and to preserve the transparency and the lightness of the formula. Nano-emulsions are commonly used in different cosmetic products, such as conditioners or lotions. They are attractive for cosmetic or consumer products because of their optical, tactile, and texture properties[23]. Nanoemulsions have more advantages than larger scale emulsions. They are transparent, possess higher stability and have better suitability to carry active ingredients due to the smaller size of the emulsion[24]. They are often used in nail polish to increase the adhesiveness, glossy nature and durability of nail polish composition[25,26].

The components of nanoemulsions are usually GRAS compounds, therefore they are considered relatively safe systems which can break down to their safe components.

Nanocapsules: These nanoscale particles which have a core-shell structure, can be used to load drugs or active ingredients[27]. It can be observed from previous study by different authors that, nanoparticulated systems show promise as active carriers due to their capacity to release drugs[28,29]; they can improve the stability of active ingredients[30] and can be biocompatible with tissue and cells when synthesized from materials that are either biocompatible or biodegradable[31].

There is a basic difference between nanocapsules and nanospheres, the former is a reservoir type system, whereas the latter is a matrix system. Therefore active ingridients are incorporated in nanocapsules and nanospheres in a different way. Polymeric nanocapsules protect the encapsulated drug or active ingredient from degradation by acting as reservoirs.

These polymer capsules could be incorporated into perfumes to release the contents on exposure to sunlight or hot weather. They are also a widely used UV filters[32]. Cosmetics manufacturers are increasing their use of nanospheres in skin care products, especially in antiaging cream[33].
Aqueous suspensions of polymeric nanocapsules are directly applied on the skin or used as intermediate products for formulations of different semisolid products, such as hydrogels and emulgels[34].

Hydrogels: They are hydrophilic polymer having 3D network structures which can absorb and retain significant amount of water and therefore swells up. This combination of polymer and water that forms a 'solid-like solution' is known as hydrogel. They are widely used in cosmetics and other personal care products. For e.g., cross -linked polyacrylamides are used in various products like sun-screen, shampoo, soap, lotion, and shaving cream[35].

Solid lipid nanoparticles: Solid Lipid Nanoparticles (SLN) are colloidal lipid carriers which are solid at body temperature[36]. SLN are made of a solid lipid core with bioactive material and this particle is stabilized by surfactants. The main advantages of SLN as promising carriers for active ingredients are: they provides better protection of unstable compounds against chemical degradations[37], such as compounds including coenzyme Q10[38] and retinol[39] can remain stable in SLNs over a long time period. It also improves the controlled release ability of active ingredient and also have capability for functioning as standalone sunscreens as UV blockers, anti aging agent etc.[40].

Nanostructured Lipid Carriers (NLC): Nanostructured lipid carriers have been identified as a potential next generation cosmetic delivery agent because it can provide enhanced skin hydration, bioavailability, stability of the agent[41]. These lipid particles have been developed by mixing solid lipids with liquid lipids. Similar to SLNs, NLCs are also capable of preventing the active compounds from chemical degradation[42]. They also possess a high occlusion factor and high level of skin adherence properties[43]. They can act as a very good moisturizer for all types of skin[44].

Dendrimers: Dendrimers are unimolecular, monodisperse, micellar nanostructures. They are use in different cosmetics and personal care products such as hair-styling gels, shampoos, sunscreens, and anti-acne products because they have excellent carrier properties[45,46]. The free amino group of dendrimers can form complex with anti-acne agents to obtain cosmetically acceptable formulations for treatment of acne vulgaris[45].

Cubosomes: Cubosomes are self-assembled cubic liquid nanocrystalline particles which contains certain surfactant with proper ratio of water. They have a "honeycombed" like structure with bicontinuous domains of water and lipid in which surfactant are assembled. Cubosomes are low viscous materials and can exist at almost any dilution level. They also have high heat stability and are capable of carrying hydrophilic and hydrophobic molecules[47].

Buckyballs: Fullerenes or buckyballs are made of carbons and looks like a hollow sphere. Strong antioxidant properties and effective quenching radical oxygen species (ROS) made fullerenes (C60) suitable active compounds in the preparation of skin rejuvenation cosmetic formulations[48]. There are various cosmetic products that contain Radical Sponge (a blend of polyvinylpyrrolidone and 1,3-butylene glycol that dissolve fullerene) and LipoFullerene such as skin lotions, essential beauty oils, creams, cleansers, makeup bases, packs, etc.[49].

However, though in the above paragraphs various potential benifits of nanomaterials in cosmetics have been discussed, but it is only the one side of a coin, the other side is, their use in cosmetics led to rising safety concerns as these materials have different physicochemical properties from their larger form. They have smaller size, larger surface area and therefore greater reactivity. These properties help to generate reactive oxygen species (ROS), including free radicals which will result in oxidative stress, inflammation, and consequent damage to proteins, membranes and DNA. More over the high dose and long persisting time of the nanoparticles in the vital organs can lead to their dysfunction[50,51] .

Previous studies have shown that carbon fullerenes, which are used in moisturizers and some face creams have even been found to be toxic to the vascular endothelial cells[52]. There are also a few reports that showed some toxic effects of inorganic nanoparticles used in sun screen, towards living body such as: damage of DNA[53], disruption of cellular function[54], production reactive oxygen species[55]. But a number of studies have shown that penetration of TiO_2 and ZnO nanoparticle limited to upper layers of stratum corneum[56-65] which is the outermost layer of skin and is made up of dead cells. Therefore, for clarity, there is a need for more research regarding the safety of nanomaterials.

3. Conclusion

It is clear that nanotechnology has the potential to bring benefits to cosmetics and personal care products and so, cosmetic companies use nanoscale versions of 32 ingredients to provide better performance of their products. But along with their enormous technological and economic potential, a debate about risks related to nanotechnologies has started. Therefore, for clarity more research work should be needed and also clear information should be provided to the consumers about the use of nanomaterials in cosmetic products more broadly.

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