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RESEARCH ARTICLE

# Exploration of Various Classes of Nanoparticles used in Cosmetic Applications

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## ABSTRACT

For the substance to provide benefits to the skin is necessary that the particles are small enough to penetrate the skin. Thus, it can maximize its capacity for regeneration, nutrition and strengthening the defenses of the skin, which also will look firmer and radiant. Collagen boosting techniques have arisen as a key market trend within the anti-aging market, with consumers striving to achieve the best results possible from skin care treatments, instead of using more drastic plastic surgery methods to hide signs of aging. The applications of nanotechnology and nanoamaterials can be found in many cosmetic products including moisturisers, hair care products, make up and sunscreen. The application of nanomaterials in cosmetic products has been the subject of continuous discussion in the media, scientific circles and among policy makers for the past few years. Toxicity issues have been raised due to conflicting research papers about the safety of nanomaterials and lack of agreement between researchers on whether the nanomaterials are safe for dermal use. There are a number of classes of nanoparticles used, or proposed for use, in cosmetic applications. In cosmetics there are currently two main uses for nanotechnology. The first of these is the use of nanoparticles as UV filters. Titanium dioxide ($TiO2$) and zinc oxide (ZnO) are the main compounds used in these applications. The second use is nanotechnology for delivery. Liposomes and niosomes are used in the cosmetic industry as delivery vehicles. Newer structures such as solid lipid nanoparticles (SLN) and nanostructured lipid carriers (NLC) have been found to be better performers than liposomes. In particular, NLCs have been identified as a potential next generation cosmetic delivery agent that can provide enhanced skin hydration, bioavailability, stability of the agent and controlled occlusion. Encapsulation techniques have been proposed for carrying cosmetic actives. Nanocrystals and nanoemulsions are also being investigated for cosmetic applications. Present paper deals with exploration of various cosmetic carriers like Transferosomes, Niosomes, Nanoemulsions, Solid lipid nanoparticles (SLNs), Nanostructured lipid carriers (NLCs), Dendrimers and hyperbranched polymers, Nanocrystals, Encapsulation technologies, Cubosomes, Nanoparticles of ZnO or TiO2 and Nanomechanical properties of hair. This research, along with better regulation and reporting, will enable consumers to choose products with confidence. This in turn will allow companies to benefit from these novel technologies in the long term while retaining customer confidence.

**Key Words:** Transferosomes, Niosomes, Nanoemulsions, Solid lipid nanoparticles (SLNs), Nanostructured lipid carriers (NLCs), Dendrimers and hyperbranched polymers, Nanocrystals, Cubosomes.

## INTRODUCTION

Development of facial wrinkles is a kind of fibrosis of the skin. Misrepair-accumulation aging theory [1, 2] suggests that wrinkles develop from incorrect repairs of injured elastic fibers and collagen fibers [3]. Repeated extensions and compressions of the skin cause repeated injuries of extracellular fibers in derma. During the repairing process, some of the broken elastic fibers and collagen fibers are not regenerated and restored but replaced by altered fibers. When an elastic fiber is broken in an extended state, it may be replaced by a "long" collagen fiber. Accumulation of "long" collagen fibers makes part of the skin looser and stiffer, and as a consequence, a big fold of skin appears. When a "long" collagen is broken in a compressed state, it may be replaced by a "short" collagen fiber. The "shorter" collagen fibers will restrict the extension of "longer" fibers, and make the "long" fibers in a folding state permanently. A small fold, namely a permanent wrinkle, then appears.

For the substance to provide benefits to the skin is necessary that the particles are small enough to penetrate the skin. Thus, it can maximize its capacity for regeneration, nutrition and strengthening the defenses of the skin, which also will look firmer and radiant.

Collagen boosting techniques have arisen as a key market trend within the anti-aging market, with consumers striving to achieve the best results possible from skin care treatments, instead of using more drastic plastic surgery methods to hide signs of aging.

The applications of nanotechnology and nanoamaterials can be found in many cosmetic products including moisturisers, hair care products, make up and sunscreen. The application of nanomaterials in cosmetic products has been the subject of continuous discussion in the media, scientific circles and among policy makers for the past few years. Toxicity issues have been raised due to conflicting research papers about the safety of nanomaterials and lack of agreement between researchers on whether the nanomaterials are safe for dermal use. There are a number of classes of nanoparticles used, or proposed for use, in cosmetic applications.

Present paper deals with exploration of various cosmetic carriers like Transferosomes, Niosomes, Nanoemulsions, Solid lipid nanoparticles (SLNs), Nanostructured lipid carriers (NLCs), Dendrimers and hyperbranched polymers, Nanocrystals, Encapsulation technologies, Cubosomes, Nanoparticles of ZnO or TiO2 and Nanomechanical properties of hair. This research, along with better regulation and reporting, will enable consumers to choose products with confidence. This in turn will allow companies to benefit from these novel technologies in the long term while retaining customer confidence.

## METHODOLOGY

In cosmetics there are currently two main uses for nanotechnology. The first of these is the use of nanoparticles as UV filters. Titanium dioxide ($TiO_2$) and zinc oxide (ZnO) are the main compounds used in these applications. The second use is nanotechnology for delivery. Liposomes and niosomes are used in the cosmetic industry as delivery vehicles. Newer structures such as solid lipid nanoparticles (SLN) and nanostructured lipid carriers (NLC) have been found to be better performers than liposomes. In particular, NLCs have been identified as a potential next generation cosmetic delivery agent that can provide enhanced skin hydration, bioavailability, stability of the agent and controlled occlusion. Encapsulation techniques have been proposed for carrying cosmetic actives. Nanocrystals and nanoemulsions are also being investigated for cosmetic applications.

## RESULTS AND DISCUSSION

**Transferosomes:** A new type of liposomes called transferosomes as shown in figure 1 (A), which are more elastic than liposomes and have improved efficiency, have been developed [4]. Transferosomes with sizes in the range of 200-300 nm can penetrate the skin with improved efficiency than liposomes [5]. These self assembled lipid droplets with elastic bilayers are capable of spontaneous penetration of the stratum corneum through intracellular or transcellular routes as shown in figure 1 (B) and have potential applications in cosmetics and drug delivery [6].

**Niosomes:**
Niosomes are non-ionic surfactant based vesicles that have a similar structure to that of phospholipid vesicles like liposomes as shown in figure 2. They can be used to encapsulate aqueous solutes and act as drug and cosmetic carriers. They are formed by the self-assembly of non-ionic surfactants in aqueous media. The application of heat or physical agitation helps niosomes to attain a closed bilayer structure [7]. The hydrophobic parts are shielded from the aqueous solvent while the hydrophilic head groups are in contact with it. They have been used for the delivery of anti-inflammatory agents [8] and anti-infective agents [9]. They have also been used to enhance transdermal drug delivery. Niosomes were developed and patented by L'Oréal in the 1970s and 80s [10].

**Nanoemulsions:**
Nanoemulsions are dispersions of nanoscale droplets of one liquid within another [11]. These emulsions are metastable systems whose structure can be manipulated based on the method of preparation to give different types of product e.g. water-like fluids or gels [12]. Nanoemulsions have a number of advantages over larger scale emulsions. They can be stabilised to increase the time before creaming occurs, therefore increasing the shelf life of products containing them [13]. They are transparent or translucent, and have a larger surface area due to the small particle size. It has been found that the smaller the size of the emulsion, the higher the stability and better suitability to carry active ingredients [14]. The components of nanoemulsions are usually GRAS compounds, therefore they are considered relatively safe systems which can break down to their safe components.

**Solid lipid nanoparticles (SLNs):**
Solid lipid nanoparticles (SLNs) are nanometre sized particles with a solid lipid matrix. They are oily droplets of lipids which are solid at body temperature and stabilised by surfactants. Their production is a relatively simple process where the liquid lipid (oil) in a nanoemulsion is exchanged by solid lipids [15].

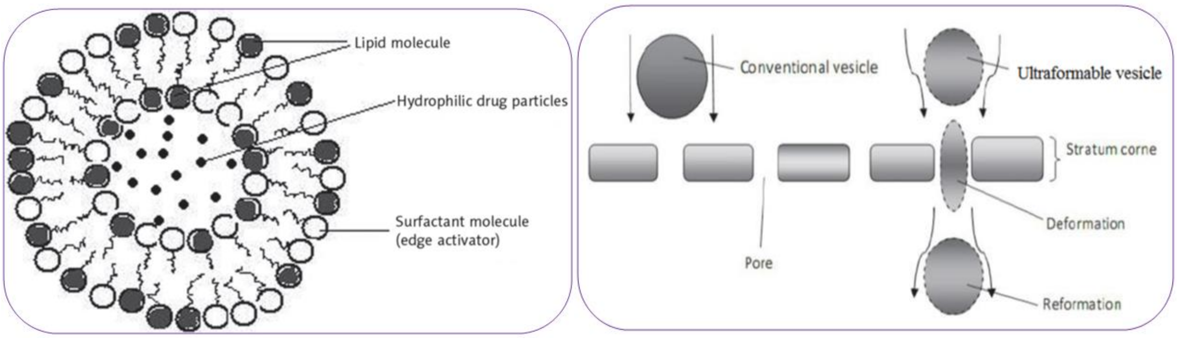


**Fig 1. (A) Transferosomes. (B) Penetration of Transferosomes.**

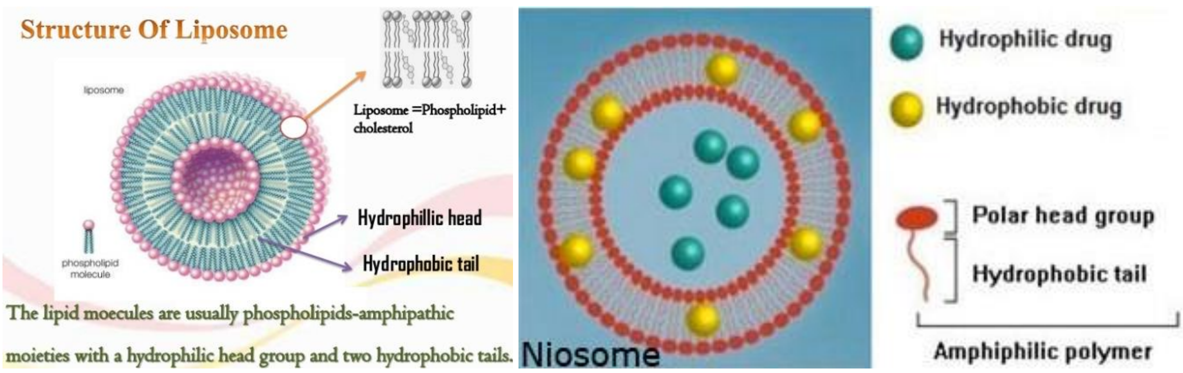


**Figure 2. Stucture of Liposome and Niosome**

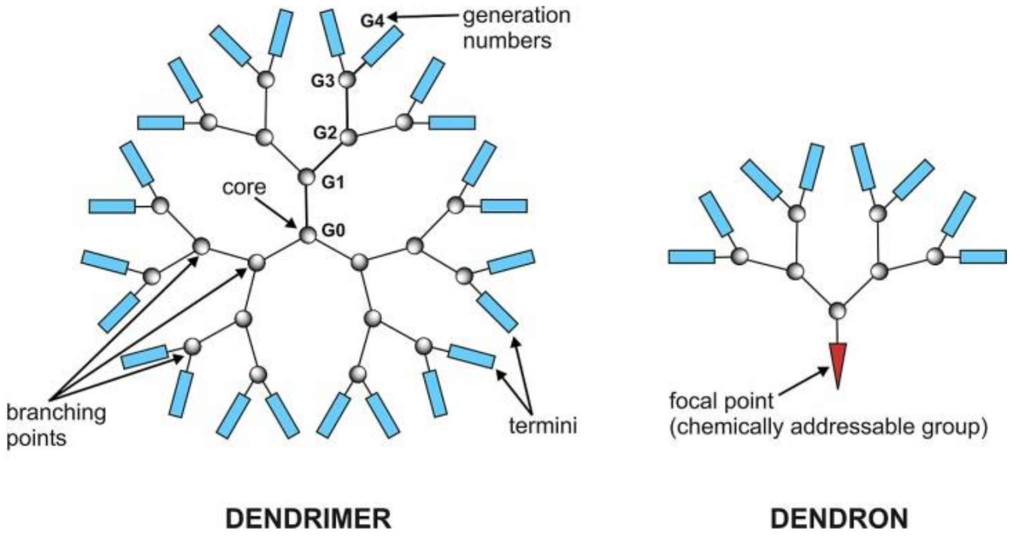


**Figure 3. Denrimer and Dendron**

**Nanostructured lipid carriers (NLCs):**

In order to overcome issues associated with SLNs, a second generation of lipid particles has been developed by mixing solid lipids with liquid lipids. These are known as nanostructured lipid carriers (NLCs). Müller et al. [15] suggested that SLNs are better for applications such as UV protection where a high level of crystallinity is required for the carrier. Similar to SLNs, NLCs are also capable of preventing the active compounds from chemical degradation [16]. They also possess a high occlusion factor and high level of skin adherence properties. When the particles adhere to the skin a thin film layer is created which prevents dehydration. As the size of the particles decreases the occlusion factor increases. Lipid nanoparticles have been found to increase the penetration capabilities of active compounds compared to microparticles [17]. The lubricating effect and mechanical barrier of lipid nanoparticles are also desired in skin care applications for reducing irritation and allergic reactions. Lipid nanoparticles can make products appear white, rather than yellowish, which is more desirable for consumers [18].

**Dendrimers and hyperbranched polymers:**

Dendrimers and hyperbranched polymers have also been considered for use in the cosmetic industry. Dendrimers are unimolecular, monodisperse, micellar nanostructures, around 20 nm in size, with a well-defined, regularly branched symmetrical structure and a high density of functional end groups at their periphery as shown in figure 3. They are known to be robust, covalently fixed, three dimensional structures possessing both a solvent-filled interior core (nanoscale container) as well as a homogenous, mathematically defined, exterior surface functionality (nano-scaffold) [19]. L'Oréal have a patent for a formulation containing hyperbranched polymers or dendrimers which form a thin film when deposited on a substrate [20]. They have also developed a formulation comprising of a tanning agent and dendrimers for artificial skin tanning [21]. Unilever have a patent for hydroxyl-functionalised dendrimers from polyester units to create formulations for use in sprays, gels or lotions [22]. Several patents have been filed for the application of dendrimers in hair care, skin care and nail care products [23, 24].

**Nanocrystals:**

Nanocrystals have been used in the pharmaceutical industry for the delivery of poorly soluble actives. 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. This dermal use of nanocrystals is protected by patents [25]. Cosmetic manufacturers are harnessing the enhanced antibacterial properties of nanosilver in a range of applications. Some manufacturers are already producing underarm deodorants with claims that the silver in the product will provide up to 24-hour antibacterial protection. Nano-sized gold, like nanosilver, is claimed to be highly effective in disinfecting the bacteria in the mouth and has also been added to toothpaste.

**Encapsulation technologies:**

Encapsulation technologies have been widely used for a long time in the pharmaceutical industry for drug delivery applications. The emergence of nanotechnology and the availability of novel tools have paved the way for new type of particles which can be used for targeted delivery and that can carry drug payloads for localised action. Such nanosized particles which have a shell and an interior space that can be used to load drugs are called nanocapsules. Hydrophobically modified polyvinylalcohol 10 000 (PVA) with fatty acids (FAs) have been used to create polymeric nanoparticles for cosmetic applications [26]. The trend in the skincare applications of such polymers is moving from self repair (those that repair the skin damage according to changes in the environment using nanoencapsulation, controlled release etc.) to self predicting polymers that can predict future changes and change their property accordingly to prevent the damage. An example of this is a hydrogel developed by Hu and co-workers [27] which can respond to temperature and be used as a facial mask.

**Cubosomes:**

Cubosomes are discrete, sub-micron, nanostructured particles of bicontinuous cubic liquid crystalline phase [28]. Bicontinuous cubic liquid crystalline phase is an optically clear, very viscous material that has a unique structure at the nanometer scale [29]. It is formed by the self assembly of liquid crystalline particles of certain surfactants when mixed with water and a microstructure at a certain ratio. Cubosomes offer a large surface area, low viscosity and can exist at almost any dilution level. They have high heat stability and are capable of carrying hydrophilic and hydrophobic molecules [30]. Combined with the low cost of the raw materials and the potential for controlled release through functionalisation, they are an attractive choice for cosmetic applications as well as for drug delivery. However, at present cubosomes do not offer controlled release on their own [31]. They have also been modified using proteins [32,33]. A number of companies including L'Oréal [34], Nivia [35- 38] and Procter and Gamble are investigating cubosomes for cosmetic applications. Despite this interest, cubosomes have not yet led to products [39].

**Nanoparticles of ZnO or TiO2:**

Zinc oxide (ZnO) and titanium dioxide (TiO2) particles have been widely used for many years as UV filters in sunscreens. Recently, nanoparticles of these oxides have become popular as they retain the UV filtration and absorption properties while eliminating the white chalky appearance of traditional sunscreens. Products using nanoparticles of ZnO or TiO2 are transparent so have increased aesthetic appeal, are less smelly, less greasy and more absorbable by the skin. A number of modifications to the standard ZnO or TiO2 UV protection system have been reported. Dispersing carnauba wax nanoparticles with TiO2 nanoparticles was found to increase the sun protection factor (SPF) [40]. Nanphase Technologies, who supply nanoparticles to companies including BASF, produce controllable polymeric nanocrystals of ZnO with a size less than 35 nm for personal care applications [41]. Other nanoparticles have been developed for UV protection. Rohm and Haas produce hollow styrene acrylate copolymer nanoparticles, ~300 nm in size, that are reported to increase SPF by about 70 % [42].

**Nanomechanical properties of hair:**

Nanotechnology has been used to study the mechanical characteristics of hair. Understanding the differences between hair types allows cosmetic companies to create products to suit individual hair types (e.g. ethnic differences between Caucasian, Asian and African hair) as these can respond differently to activities like shampooing, styling or colouring. The hair care industry is also interested in the effect of water on the nanomechanical properties of hair. Bhusan et al. have conducted nanoscratch tests, using Nano Intender II (MTS Nanosystems), to understand properties of different types of hairs at the nanoscale [43].

## CONCLUSION

The application of nanomaterials like Transferosomes, Niosomes, Nanoemulsions, Solid lipid nanoparticles (SLNs), Nanostructured lipid carriers (NLCs), Dendrimers and hyperbranched polymers, Nanocrystals, Cubosomes, Nanoparticles of ZnO or TiO2 in cosmetic products can be done provided newly introduced cosmetic products should be tested extensively in laboratories to ensure optimum safety, efficacy and quality. Products should comply with the most stringent international regulatory requirements, and are of the highest safety, ethical and environmental integrity.

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