The Emerging Trends of Nanoscience in Cosmetics

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ABSTRACT

Nanotechnology has evolved as one of the novel technologies in today’s world. The tiny nanosized materials have the potential to achieve seemingly difficult feat. Consequently it has found a vast application in various commercial fields like foods, sunscreens, cosmetics, antimicrobial and antifungal preparations, wear-resistant coatings and paint, diagnosis, imaging and drug delivery. Cosmetic industry has been making a lot of development using this novel technology and a new term known as ‘nanocosmetic’ has come into use. Sunscreens, moisturizers, body lotions, anti-aging and anti-wrinkle creams are now engineered using nanotechnology for better results. In the past few decades there has been an increase in the number of nanotechnology based cosmetics or and this trend will only increase in the future. In this review emphasis is made on the use of various types of nanomaterials namely nanoemulsions, liposomes and nanogels in cosmetics, their benefits products based on these nanomaterials and the future scope of the technology.

Keywords- Liposomes, Nanocosmetics, Nanoemulsion, Nanogel, Nanomaterials, Nanoscience, Nanotechnology.

INTRODUCTION

Nanotechnology has found application in various commercial products. In 2009, more than 13% of the total one thousand nanotechnology based products were classified as cosmetic products [1]. The huge influence of nanocosmetics is due their enhanced properties like color, transparency, texture, increased shelf-life, etc. [2]. Nano materials are being developed because they possess different properties than their larger-sized counterparts. Properties like improved texture, enhanced stain resistance, improved aesthetics, longer shelf life and improved UV protection enable us to use nanoparticles in cosmetic products. Modern cosmetics nanomaterials such as nanoemulsions, nanocapsules, liposomes, carbon nanotubes vesicles are loaded with the traditional cosmetic materials [3]. The use of titanium oxide and zinc oxide nanoparticles in sunscreen is widespread as they provide protection against the harmful UVA and UVB more efficiently than the conventional sunscreen. Cosmetic companies like Lancome, L’Oreal, Dior, Kara Vita, have been manufacturing various nanotechnology based products (i.e. antiaging, antiwrinkle, moisturizers, sunscreen, cleanser, face mask and face gels).

Cosmetic companies use nanomaterials like nanoemulsions, liposomes, nanogels, nanocapsules, dendrimers, etc. which have been discussed in detail. Various research and studies in nanotechnology have enabled us to use nanomaterials in cosmetics and biomedical applications.
1. NANOEMULSION:

A nanoemulsion is a thermodynamically stable liquid dispersion of oil and water phase in combination with a surfactant. Nanoemulsions are transparent because the droplets of the dispersed phase have a size smaller than 25% of the wavelength of visible light [4]. The basic idea of the preparation of nanoemulsion is to reduce the droplet size of the dispersed phase below 600nm. Nanoemulsions can be formulated according to the requirement (and can be produced as foam, gel, spray, creams etc.), and can be used to increases the shelf-life of the product, which makes them a suitable choice for cosmetic products. Nanoemulsions are used in cosmetics because there is no inherent creaming, sedimentation, flocculation or coalescence that are present in macro emulsion.[4] They are increasingly used as drug delivery due to their controlled delivery and the optimized dispersion of active ingredient in particular skin layer. Nanoemulsions allow skin penetration of active ingredients and thereby increase their concentration in the skin [5]. These nanomaterials have also been reported to be ideal drug delivery systems for drugs such as steroids, hormones and antibiotics. As a drug delivery system nanoemulsions can prove to be useful in treating signs of aging, wrinkles and other skin related problems.

![Graph showing increase in hydration of different products](image)

**Fig 1:** Increase in Hydration of fore-arm Stratum Corneum after 1 and 24 h of treatment with different products [6].

Nanoemulsions are being widely used in cosmetics due to their hydration power, and the rate of penetration. A comparative study on the hydration power of nanoemulsion, body lotion and body water showed that the hydration power of nanoemulsion is higher than the other two [6].

Nanoemulsions can be classified as
- Oil in Water (O/W) nanoemulsion where oil droplets are dispersed in aqueous phase
- Water in Oil (W/O) nanoemulsion where water droplets are dispersed in oil phase
- Bi-continuous nanoemulsion where oil and water are continuous phases within the system. [7]

1.1 Preparation: Preparations method is crucial for the formation and stability of nanoemulsion. Nanoemulsions are prepared using high energy methods and low energy methods. High energy methods like 1.1.1 High Pressure Homogenization, Microfluidization, and ultrasonication require significant energy while the low energy methods like phase inversion temperature and emulsion inversion point, involve complex inversion from one form to another and depend on the system composition properties [8]. A new method has recently been used called the bubble burst method.

1.1.2 High Pressure Homogenization (HPH): This is the most common high energy method of producing oil in water nanoemulsions containing <20% oil content [9]. Firstly, a coarse emulsion is produced using a high shear mixer. Then the emulsion is fed directly into the inlet of the high pressure homogenizer. The
homogenizer pulls the coarse emulsion into a chamber and then forces it through a narrow valve at the end of the chamber. As the coarse emulsion passes through the valve it experiences forces that breaks down the larger droplets into smaller ones [8].

1.1.3 Microfluidization: This patented technology makes use of a device called microfluidizer. The device works on the principle of dividing a pressure steam into two parts, passing each part through a fine orifice. The flows are directed at each other in the interaction chamber. The microfluidizer uses a high pressure to guide the flow through microchannels towards the impingement area. This force creates a high shearing action which provides a very fine emulsion. [10]

1.1.4 Ultrasonication: This technology makes use of ultrasound to break the large sized oil droplets into smaller ones. The intense shear forces necessary for the nanoeumulsification are generated by high-power ultrasound due to acoustic cavitation. Cavitation is the formation and collapse of vapor cavities in a flowing liquid [10]. This produces violently and asymmetrically imploding bubbles and causes micro-jets that impinge one liquid into the other.

1.1.5 Phase Inversion Methods: In this low-energy method, a fine emulsion is produced by inducing a phase-inversion from a W/O to O/W form. The technique involves two methods; Phase inversion temperature (PIT) and Emulsion inversion point (EIP). PIT method involves a transitional phase inversion where the surfactant properties are altered by adjusting a formulation variable, such as temperature, pH, or ionic strength whereas, the EIP method involves a phase inversion where the ratio of the oil-to-water phases is altered while the surfactant properties remain constant [8].

2. LIPOSOME:

Liposomes are spherical shaped vesicles which consists of one or more phospholipid bilayers. Liposomes are used in a variety of cosmeceuticals because they are biocompatible, biodegradable, nontoxic, and flexible vesicles and can encapsulate active ingredients easily. While many studies suggest that liposomes penetrate the stratum corneum and viable epidermis, Cevc & Blume (1992) claimed that certain types of lipid vesicles could penetrate into the deep layers of the skin and might progress far enough to reach the systemic circulation [11]. So we can use both these aspects to our benefits. If liposomes can easily penetrate into the dermis and beyond intact, this can enable the transdermal drug delivery. The property of penetration of liposomes into stratum corneum and viable epidermis is already used in cosmetic products such as moisturizers, hair shampoos, creams, lotions etc. Nowadays a large number of liposomal products are available in the market such as liposomal B complex sprays, liposome gels, antiwrinkle creams.

![Fig 2. Structure of liposome showing a phospholipid bilayer surrounding an aqueous][12].

A new concept of elastic liposomes has come into picture since the 1990s. Elastic liposomes grant the ability to deform and flow through narrow skin pores to the conventional liposomes. It has been found that these deformable fluid vesicles enhance skin permeation and carry the active compound into deeper layers of the skin. Deformable liposomes are composed of phospholipids and an edge activator or other surfactant
molecules that give the membrane its characteristic deformability or elasticity [13]. The main concern regarding liposome applications on the skin is the topical, percutaneous or transdermal fate of the vesicles. Many controversial results have led to uncertainties regarding the use of liposomes as transdermal carriers. Some studies suggest that these transdermal carriers can penetrate through the layers of skin and make their way into the bloodstream, which can Controversial results using different drugs have led to uncertainties about the real capability of conventional liposomes to act as transdermal carriers. L’Oreal and Christian Dior have been formulating liposome based anti-aging formulations like creams, lotions, gels, and hydrogels for topical use since 1986 [14].

3. NANOGEL:
Nanogels are spherical shaped polymeric structures which can be used in various biomedical applications. Nanogels have the ability to absorb water and swell, which increases the drug loading capacity. Nanogels can be used as drug delivery systems for carrying drug to the required site. Nanogels have the property of swelling and degradation with flexible size, large surface area and high water content [15]. Nanogels occur in the form of three-dimensional structures in which drugs can be entrapped. Nanogels can be classified on the basis of their structure into: simple nanogels, hollow nanogels, multilayer nanogels, core-shell nanogels, and functionalized nanogels [16]. There are various mechanism for the release of drug from the nanogels like pH-responsive mechanism, thermostensitive and volume transition mechanism and diffusion. In pH responsive mechanism, for e.g., glucose-mediated insulin delivery system is composed of glucose oxidase, catalase, with chitosan and alginate polymer. The polymer used in the system is insoluble at neutral pH. As pH became acidic, the polymer swells and the drug starts to release from the system.

3.1 Synthesis:
3.1.1 Photolithiographic technique: The photolithographic method requires the development of techniques for surface treatment of stamps or new materials for replica molds to permit the release of molded gels from stamps or replica molds [17]. This method consists of the 5 steps. In the first step the UV crosslink able polymer is used, which possess low surface energy, as a substrate is released on the pre – backed photo resist coated water. In the second step the silicon water is molded by the polymer and exposed it to the intense UV light. In the third step, the thin interconnecting film layers are uncovered by removing the quartz template. In the fourth step, the remaining thin layer is removed by a plasma containing oxygen that oxidizes it. In last step the buffer solution of the dissolution the fabricated particles are directly collected [18,19]

3.1.2 Micromolding: The methods are similar to photolithographic techniques. However, they can minimize the need to use costly lithographic equipment and clean room facilities. Moreover, by controlling the features on a mold stamp, they enable control over the size and shape of the product, which are important for biomedical applications [20].

3.1.3 Microfluidic Method: The methods require the fabrication of microfluidic devices by soft lithography using elastomeric materials, particularly PDMS or polyurethane elastomers as building blocks. The devices generally consist of inlets for monomers (or oligomers) and continuous liquids, and microchannels with a tapered junction where two immiscible phases are merged. Emulsification of monomers by breaking up liquid threads to droplets and in-situ crosslinking of the resulting droplets by photopolymerization or polycondensation are the two general steps involved in the continuous microfluidic preparation of microgels. Confinement of droplets, variation of flow rates of liquids, and precise control of reaction time are key parameters to generate monodisperse particles with a variety of shapes and morphologies. More recently, the microfluidic preparation of complicated nanostructured particles such as Janus and ternary particles has been reported [20].
4. NANOTECHNOLOGY BASED COSMETICS:

At present, many cosmetic products are produced using nanotechnology. These products are made in form of liposomes, nanoemulsions, nanogels, nanocapsules, and various nanomaterials.

4.1 Sunscreen: UV radiations from the sun comprises of 95 percent of UVA. UVA radiations play a major role in skin aging and wrinkling. In some cases it may even initiate and contribute to skin cancer. UVB radiations cause skin reddening and sunburn and plays a key role in development of skin cancer [22]. Insoluble nanoparticles of titanium dioxide (TiO2) and zinc oxide (ZnO) are used to provide protection against the harmful UVA and UVB radiations from the sun. The advantage of using TiO2 and ZnO nanoparticles is that the particle size ranges from 1-100 nm which results in a transparent formulation. This helps overcome the conventional opaque sunscreen which involves micro-sized TiO2 and ZnO particles. Studies suggest that TiO2 nanoparticles remain at the surface of the skin or the outer layer of the stratum corneum. Similarly, studies on ZnO nanoparticles did not show skin penetration. At present, studies suggest that there is no potential harm caused by the insoluble TiO2 and ZnO nanoparticles.[3,23,24,25] In a nutshell, sunscreen containing insoluble nanoparticles of TiO2 and ZnO are transparent, less greasy and appeal aesthetically.[12]

4.2 Anti-aging: Photoaging is premature aging of the skin caused by repeated exposure to ultraviolet radiation (UV) primarily from the sun, but also from artificial UV sources [26]. The aging Anti-aging products are used to overcome the aging of the skin. To improve the stability and efficiency of anti-aging products, vesicular nanocarriers such as liposomes, nanocapsules and nanoemulsions have formulated for topical use. Many anti-aging products contain bioactives and anti-oxidants. Bioactives are required to counteract the injuries caused by the reactions in which the singlet oxygen generated on the skin surface react with the free amino acids and oligopeptides and bind with polysaccharides. Anti-oxidants are basically used to revert the depletion of anti-oxidant reservoirs and to reduce the effect of free-radicals [27]. Fullerene, coenzyme Q10 (CoQ10), Vitamin-C and E are widely used antioxidants in cosmetics [28]. L’oreal, Estée Lauder, Lancôme are some of the companies producing anti-aging products.

4.3 Hair Products: Hair product are being produced using nanotechnology for shinier, smoother and healthier hair. Sericin nanoparticles are used in formulations like shampoos and conditioners, as they are claimed to repair damage. These nanoparticles are prepared from the degumming of Bombyx mori silkworm moth [29]. Metal nanoparticles have also been claimed to be useful in treating hair loss. A composition comprising sliver nanoparticles and Polygonum multiflorum Thunb extract can be used for increasing hair growth or treating alopecia areata [30].

Figure 3: Drug loading and drug release in nanogels [21]
5. FUTURE OF THE TECHNOLOGY:

Cosmetics have been used since ancient times and will be used in future as well. Since the market for nanocosmetics has a lot of potential, it is evident that the technology continues to develop. With the advent of nanocosmetics, the cosmetic industry is growing. Advancements are being made in sunscreens to provide better protection from UV rays and to avoid any kind of cytotoxic and genotoxic effects. Nanoencapsulation of traditional organic UV filters is a more recent technological approach to improving the skin retention, photostability and UV blocking ability of the free molecules. Nanoencapsulation enhances the retention of different organic sunscreens in the upper layers of the skin and alters the penetration and release profiles of the active molecule according to the design and material of the particle. There are many possibilities of developing nanoemulsions that act on specific targets, have better skin penetration for more efficient drug delivery and minimize the side effects. Use of elastic liposomes with in cosmetics is

5. CONCLUSION

Nanotechnology is developing at a very fast pace and it is evident that a lot can be achieved in future. Nanoemulsions, liposomes and nanogels have opened up new opportunities for a better drug delivery. Cosmetic industry has improved as more effective products have been formulated. Target specific nanoformulations are being developed. The coming era will be an Era of Nanotechnology and technology will improve. Research and studies are being done to produce nanomaterial formulations that can make stop hairfall, provide strength and shine to hair. Skincare cosmetics are formulated to counter the signs of aging. In a nutshell, it is only the beginning of this novel technology and loads of new inventions and researches are yet to be done to use it to the full potential.

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