Common Nanocarriers and Their Advantages, Disadvantages and Applications

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Abstract. With the improvement of people's quality of life, skin management and skincare products have become the focus and topics of more and more people's attention. Among them, the most popular products are anti-aging products. However, the main ingredients in anti-aging products are Antioxidants (AOs), and the irritation and penetrability of the antioxidants might prevent them from being used on the skin directly. With the development of nanotechnology, nanocarriers are created to solve these problems. Herein, liposomes, nanoemulsions, solid lipid nanocarriers (SLNs) and nanostructured lipid carriers (NLCs) are summarized. Besides, relative applications, benefits, and drawbacks are discussed. This review is intended to deepen the understanding of nanocarriers and promote safer applications of nanocarriers in the cosmetic industry.

Keywords: Cosmetic Industry, Nanocarriers, Liposome, Nano Emulsion, Solid Lipid Nanocarriers, Nanostructured Lipid Carriers.

1. Introduction

With the development of material technology, a growing number of nano-based goods have been created, utilizing a wide range of nanomaterials with various compositions, forms, and sizes. Any "insoluble or bio-persistent and purposely made material having one or even more external dimensions, or perhaps an interior structure, on the scale between 1 to 100 nm," is typically referred to as a nanomaterial. Because these nanoparticles have new characteristics different from those of large particles, these changed characteristics include colour, transparency, solubility, and chemical reactivity. Therefore, nanomaterials are widely used in the cosmetics, personal care, and pharmaceutical industries. However, nano carriers are also one of the nanomaterials used as a transport module for drugs and other substances. Commonly used nano carriers include micelles, nanoemulsions, liposomes and other substances [1].

Nanocarriers are typically used in cosmetics to address problems with bioactive substances, including their poor stability, solubility in water or penetrating ability, or the requirement to manage their release. The development of high-quality products was revolutionized by the advent of nanotechnology, a key technological advancement whose application is now widespread in the cosmetics sector. [2]. Since 2000, the global market for cosmetics has had significant growth with a compound annual growth rate (CAGR) of 4.5% and annual growth rates ranging from 3.0 to 5.5%. [3, 4]. But there has frequently been widespread distrust because to questions about potential long-term [5] damage and worries about the true benefits of nanoparticles in product performance. [9] As a result, the cosmetics industry started to be cautious about publicly promoting nanotechnology and frequently avoided mentioning substances made from nanoparticles.

In this review, common types of nanocarriers in skincare products are summarized. Next, the structure, characteristics, and advantages of liposomes, nanoemulsions, solid lipid nanocarriers (SLNs) and nanostructured lipid carriers (NLCs) will be presented. Furthermore, several practical applications will be listed. Finally, their disadvantages will be briefly mentioned. This review will not only give deep insight into use of nanocarriers, but also advice on how to use them safely.

2. Liposome

The size of the liposome is around 20 to 100 nanometres. Liposomes are made of phospholipid bilayers, as it contains polar head which is hydrophilic and hydrophobic tails. There are hydrophobic substances among the bilayers and hydrophilic materials inside and outside of the layers. There are few benefits when using liposome as the carriers of the ingredients. As liposome absorbed into our skin, its encapsulation nature provides a better penetration ability, it would reduce the irritation and maximize the dose when reaching the epidermal layer of human skin. Moreover, the liposome would support a longer residence time when locating at the epidermis and dermis to keep a slow release. Also, the liposome protects the ingredients from metabolic degradation in the subcutaneous tissue. Through in situ and in vitro studies of contact with cells, the main liposome interactions with cells are simple adsorption, through interactions with cell surface components, by electrostatic forces, or through a non-specific weaker hydrophobicity, or after endocytosis. Fusion with the plasma cell membrane by insertion of the lipid bilayer of liposomes into the plasma membrane, with concomitant release of the liposomal content into the cytoplasm. Another possible interaction is the exchange of components between the two molecular layers, such as cholesterol, lipids and other components. It is often confusing to determine which mechanism is at work, however, and it is possible that multiple mechanisms are at work simultaneously [10]. The most important path of liposome-cell interactions is through endocytosis, there are four stages of the interaction. It is believed that the uptake of liposomes by cells is mediated by their adsorption on the cell surface and subsequent endocytosis [8]. Firstly, the lipid layer of the eukaryotic membrane cooperates with the liposome via fusion, the chemicals released by the liposome moves inside the cell. Moving on the next step, the cell adsorbs the content released by the liposome depending on the electrostatic forces of attraction. Then, when the surface of liposome gets attached to the surface of the cell membrane, the lipid inside gets exchanged. Lastly, the phagocyte cells engulf the liposome which is a process called endocytosis [9].

Also, there are several strategies of preparing the liposome. For instance, French pressure cell: extrusion, Freeze-thawed liposomes, Lipid film hydration by hand shaking, non-hand. shaking or freeze drying, Micro-emulsification, Membrane extrusion. Dried reconstituted vesicles etc. The main downside of the technique called the reverse phase evaporation method is the need to expose the material being encapsulated to organic solvents and brief ultrasonication. These sorts of conditions can lead to DNA strand breaks or denaturation of some proteins. The drawbacks of enter injection are that the population is heterogeneous and that the encapsulated compound is simultaneously exposed to organic solvents at high temperatures.

Although liposome performs variety of benefits, there are still problems exist. The solubility of liposome is low, so specific solvent might be required. Also, the production cost of liposome is expensive as it requires high standard of equipment and conditions, there is still needs to find a financial friendly mechanism to produce liposome.

3. Nanoemulsions

Compared with liposomes, nanoemulsions (NEs) are isotropic dispersed systems of two non-miscible liquids, commonly consisting of an oil-in-water system (O/W), or water-in-oil (W/O) system, forming droplets or oily phases on nanoscale [8]. And they are metastable systems, their structures can be manipulated according to the preparation method. We can use high-pressure homogenization and ultrasonication method (high-energy method), spontaneous emulsification (low-energy method) and membrane emulsion to prepare nanoemulsions [8]. In cosmetical industries, because its smaller particle size provides higher stability, it is more suitable for carrying active ingredients, so that they can also extend the shelf life of products [10].

Now nanoemulsions has been applied to some cosmetic products. For example, using an ultrasonic treatment approach, Silva et al. (2013) created a nanoemulsion-based sunscreen with avocado oil droplet micelles as the active ingredient [11]. A system of nanoemulsions was developed by Bernardi et al. (2011) using micellar nanoparticles from rice bran oil, a common cosmetic ingredient for anti-aging & sunscreen applications [12]. Recently, lamer presents the hydrating infused emulsion, formulated with a featherlight texture to boost cell renewing, make skin keep all-day healing moisture.

Although nanoemulsions has been widely used, it still has some defects. Due to the high cost and complexity of production, high energy is required to generate small droplets [13]. Because most of them are prepared through the emulsification of high-speed emulsifiers, the requirements for equipment investment and manufacturing process are very high. Another problem is that nanoemulsions is a liquid preparation, which is not as stable as solid preparation, so its shelf life is often very short.

4. Solid Lipid Nanocarriers (SLNs) and Nanostructured Lipid Carriers (NLCs)

Mostly, SLNs are made of solid lipid, an emulsifier and aqueous substance. However, due to its low payload in some drugs and the tendency of drugs to be expelled during storage, an upgrade of SLNs called NLCs are created [14]. It has both solid and liquid lipid core, which is boosting the amounts and loading efficiency of AOs [15]. The following methods are used to prepare SLNs and NLCs: (i) high-shear homogenization and ultrasound [16]; (ii) microemulsion [17]; (iii) solvent emulsification [18]; (iv) high pressure homogenization [19]. SLNs also possess the similar advantages as NEs and liposomes, they are: (i) controlled release of AO for more than a few weeks; (ii) boosting stability; (iii) with both hydrophilic and lipophilic ingredients; (iv) possibility of large-scale production and sterilization; (v) non-biotoxicity [14, 20, 21].

Here are some applications of SLNs and NLCs in cosmetic industry. Pallavi V. Pople and Kamalinder K. Singh used high pressure homogenization method to prepare vitamin A palmitate-rich SLN, and their results confirmed that vitamin A palmitate encapsulated in SLN penetrates the epidermis without causing skin damage and easily acts in the dermis [22]. Güney, G. et al., for instance, demonstrated that SLNs protects vitamin C from degradation caused by air and light. They are prepared by hot homogenization method; the lipid type is compritol and the surfactant is Tween 80 [23]. The authors hypothesized that SLNs helps the skin to enhance the absorption of vitamin C. More recently, Rabelo, R. S. et al. developed a NLCs which were obtained by melt emulsification a carriers of Vitamin D. They chose glyceryl monostearate as their lipid type and Tween 80 as their surfactant [24].

However, SLNs and NLCs still have some disadvantages. Because of their complex crystallization structure, the loading efficiency decrease. NLCs sometimes faced the problem of particle growth. Another problem with NLCs is that, due to their low viscosity, their aqueous dispersions may cause poor retention capacity on the skin. [20].

5. Conclusion

In the late 1980s, nanotechnology was widely introduced into the global cosmetic market due to its advantages, such as increased retention of loaded compounds on the skin. However, there is still no clear definition of nanomaterials as ingredients in cosmetics, and each country has its laws governing makeup. At the same time, as each individual has a different skin type, different people have different tolerances to cosmetic ingredients, such as skin malabsorption, which may lead to a range of skin diseases. Therefore, some countries and regions of the world, such as the European Union, still insist on assessing the safety of nano-ingredients in cosmetics. We believe that this series of safety assessments are essential and that the dosage should be tailored to the various skin types of the consumers in each region. At the same time, the application of nanoparticles in cosmetics still holds great prospects, and the search for lower-cost preparation, large-scale production methods, and greater loading efficiency are several future research aims into nanotechnologies.

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