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Nanoparticles in the Beauty Industry: Types, Applications, and Future Perspectives

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Abstract: Different types of nanomaterials, such as nanosomes, liposomes, fullerenes, etc., are widely used in the beauty industry due to their unique advantages in color, transparency and solubility. This article analyzes the different types and functions of nanoparticles and their specific applications. The results show that nanoparticles used in cosmetics and skin care products have a variety of effects, such as reflecting ultraviolet rays, changing the color of the skin surface or anti-aging by scavenging free radicals. This article introduces information on six types of nanoparticles and provides a reference for the use of these nanoparticles in the beauty industry. Although the application of nanotechnology can promote skin cell respiration, strengthen the production of fibroblasts and collagen, and prolong the effect of hair dyeing, etc. However, with the rapid development of nanotechnology, consumers are increasingly concerned about the potential health hazards of nanoparticles that may penetrate the skin. In the future, as nanotechnology continues to mature in the field of beauty, further reducing costs and improving product safety will become the main purpose of future research. The development of nanotechnology products suitable for different skin types and needs, as well as the realization of more effective antioxidant and sunscreen functions in products, will become an important direction for future research.

Keywords: nanoparticles,cosmetic,beauty industry

1. Introduction

After over 20 years of basic research in nanoscience, nanotechnology applications are delivering many benefits to society in unexpected ways. Nanotechnology plays an important role in improving, even revolutionizing, many technology sectors like medicine, cleaning water, improving batteries, and modifying food. It is used the most in electronics and IT with flexible electronics, high-definition displays, and improved memory on devices [1]. Nowadays, more people pay attention to their physical image, and people's requirements for the beauty industry are getting higher and higher. Nanotechnology is important in the beauty industry, like helping cosmetic products be more stable and maintain not damaging the hair. Nanotechnology has abilities with enhanced properties at the nano level, including solubility, color and transparency. These lead nanoparticles have wide spread in cosmetics. There are many different types of nanomaterials used in cosmetics including nanosomes, liposomes, fullerenes, solid lipid nanoparticles, etc.In the science of cosmetics formulation, applications of nanotechnology like dendrimers and nanoemulsions are brilliant examples of nanoform particles [2]. In addition, using nanoparticles as a carrier can assist the components in

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product formulations to penetrate more deeply, which should boost the product's performance. Among the many benefits of using nanotechnology in cosmetics are the ability to safely strengthen the structures that connect the epidermis and dermis, enhance skin cell respiration, and encourage the synthesis of collagen and stronger fibroblasts. The advantage is that as we age, the skin becomes tighter and firmer again, giving us a more youthful appearance, better texture, and more uniform skin tone. [3]. Nanotechnology can also enhance the lasting effect of the hair dye application, and the developments recently in nanoscience and nanotechnology bring new possibilities for permanent dye hair applications. However, with nanotechnology developing, an increase in people's concern about the risk of nanoparticle penetration through the skin and potential harm to consumer health, so it must design safer nano-based beauty products. Some nanoparticles used in hair dye also contain toxicity issues that will damage the hair shaft, strip natural oils, cause brettleness and dryness. This essay will research the application of nanotechnology in the beauty industry and talk about the principles of different nanoparticles. In addition, it will mention the challenges of the nanotechnology used and come up with some prioritization schemes. To be more targeted, this essay will focus on nanoparticles in cosmetics, skincare and hair dye.

2. Type and function

There are many kinds of nanoparticles used in the beauty industry, which are usually smaller than 100 nanometers of their sizes. The smaller nanoparticles' size can bring better absorption and performance of cosmetics and skincare, and it also can extend their shelf lives and improve the quality of the products. Moreover, nanoparticles can change hair color and prevent transfollicular water loss. This section will show these different nanoparticles and analyse their structures and functions.

2.1. Glod and silver nanoparticles

Ligated metal cores are found in gold and silver nanoparticles, which are high-nuclearity metal-organic compounds. The isoelectronic nature of gold and silver and their similar atomic radius make the comparison of gold and silver mNPs appealing [3]. Gold nanoparticles are able to be synthesized in a variety of shapes and sizes, unlike most inorganic nanomaterials [4]. The use of Au and Ag-based nanoclusters is diverse due to their unique properties and simple synthetic methods. These are sometimes used for their antimicrobial properties in cosmetics and skincare, but they can also stabilize antioxidants to extend the shelf life of products. In hair dye, silver nanoparticles have strong absorption in the visible region of the spectrum due to the local surface plasmon resonance absorption phenomenon. Therefore they are used in the colouration of natural textile fibres frequently.

2.2. Titanium dioxide (TiO2) nanoparticles

TiO2 is a naturally occurring mineral. Because TiO2 is always present in white powder, it can provide a smooth appearance, increase the opaqueness of products, and is widely used to enhance the colour and brightness of products in white, such as food and cosmetics. TiO2 works well as an ultraviolet light absorber and photocatalyst. For skin sensitivity, it is regarded as non-hazardous due to its transparency and UVA and UVB absorption properties, which enable it to be used as an efficient filter in sunscreen creams. TiO2 is beneficial for skin that is sensitive and prone to redness. Because it is very unlikely to produce stinging, it is excellent for usage near the eyes [5].

2.3. Polymeric nanoparticles

The polymers are made up of thousands of repeating units. Due to its elasticity, processability, and lightness, polymer structures are commonly used. Compared to metals and ceramics, these structures

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typically have lesser mechanical properties like low strength and stretch modulus. High-modulus reinforcing fillers can be added to create polymer composites to improve the mechanical properties of these systems without compromising their desired properties [6]. Some spherical vesicles are always used to deliver anti-ageing ingredients or moisturisers more effectively by enhancing penetration into the skin because they can encapsulate hydrophobic elements and hydrophilic ones. In care products, polymers serve as rheology modifiers. Water-based formulations are commonly used to prepare these products, which usually have a low viscosity level. This is where the polymers are added to thicken and, in many cases, gel the formulation [7]. Polymersomes' inflexible and broad bilayer makes them much more stable than other nanoparticles like liposomes. The stretchiness of their membrane enables them to be competent in the guarded and embattled release of drugs.

2.4. Liposomes

In aqueous solutions, diacyl-chain phospholipids (lipid bilayer) self-assemble to form spherical or multilayered spherical vesicles known as liposomes. The hydrophilic head and hydrophobic tail of the bilayer phospholipid membrane combine to generate an amphiphilic structure. Both manufactured and natural phospholipids can be used to create liposomes [8]. Particle size, rigidity, fluidity, stability, and electricity are all aspects of liposomes that are significantly influenced by their lipid makeup. However, liposomes based on saturated phospholipids, like dipalmitoyl phosphatidylcholine, produced stiff, nearly impermeable bilayer structures. By improving penetration into the skin, spherical vesicles that can contain either hydrophilic or hydrophobic compounds are utilized to distribute moisturizers or anti-ageing chemicals more efficiently.

2.5. Nanoemulsion

Nano-emulsification is achieved by mixing two liquids that typically don't mix, such as oil and water, with a third substance that binds them and produces smaller particles as part of the process. The diameter of droplets in nanoemulsions is approximately 100 nm. Nanoemulsions possess attractive features, including stability in kinetics, flexibility in rheology, and low polydispersity. Cosmetics use nanocarriers to enhance skin penetration and aid in the solubility of active ingredients that are difficult to incorporate into formulations [9]. The droplet size is often transparent since it is significantly smaller than the wavelength of visible light. Nanoemulsions can be easily tuned to range from transparent to milky white by controlling their droplet size [10].

2.6. Fullerenes

Fullerene is an allotropic form of carbon. The most common form is a C60 molecule containing a hollow molecular sphere that is characterised by its highly conjugated structure consisting of 30 carbon double bonds [11]. It can scavenge free radical oxygen species, so they are always used in makeup formulas for skin recovery, especially sunscreen, thus helping to reduce the damage of UV light, like hyperpigmentation and wrinkles. These nanoparticles have different functions. They are used in various cosmetic and skin products and improve the efficiency and safety of people making up and skinning care. The next section will discuss applying these nanoparticles to specific products.

3. Application

3.1. Glod and silver nanoparticles

Nanosilver particles occupy 12% of the nanosized particles used worldwide in cosmetics [12]. The research shows that by targeting the respiratory chain and inducing oxidative stress with an increase in the formation of reactive oxygen species, AgNPs can adhere to the cell wall and react with the

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membrane proteins. This can damage proteins and inhibit cell growth, and the efficiency and effectivity of this property are dependent on its size and shape. For instance, triangular-shaped has better antibacterial activity than spherical and rod-shaped. Because of this fundamental characteristic, AgNPs can be utilised as a cream or gel to treat bacterially generated skin problems like acne. AgNPs are also present in some body soaps and skin cleansers that are intended for sun-damaged or acne-prone skin. It helps treat acne and lessen the appearance of age spots and the colonisation of germs and fungi. Because AgNPs have strong antibacterial properties, they are usually the active ingredients in the preparation of skin care products, toothpaste and deodorant. AgNPs and fluoride are also combined in toothpaste to encourage self-cleaning against plaque and stop the production of carriers. According to a patent review, AgNPs are added to toothpaste or dental gels at concentrations ranging from 0.0005% to 0.004% to prevent the growth of bacteria that causes cavities and offensive oral odours. AgNPs are used in anti-dandruff shampoos to stop the growth of the species of Malassezia that causes the scalp to itch and scale. They can do this by reducing Propionibacterium acnes-induced inflammation as well as the growth of Propionibacterium acnes and other microorganisms. Additionally, AgNPs can be used to treat UV-induced skin damage by being incorporated into a variety of formulations, including sunscreens, sunburn relief products, moisturisers for the hands, body, or face, and topical analgesics [13]. However, some silver nanoparticles will damage the human body because of their small particle volume that they can penetrate human tissues [14], it is necessary to have a clear understanding of the properties of AuNPs in cosmetics, as the surrounding medium is a key factor in determining their beneficial or harmful effects [15].

3.2. Titanium dioxide (TiO2) nanoparticles

The result of the experiment illustrates that TiO2 can withstand all kinds of UVA and UVB rays because it can be used as a suitable filter, and if the TiO2 particle size becomes smaller, the effect of the UVB and UVA protection will be better. In sunscreens, TiO2 particles are often made smaller to be less visible on the skin while still protecting you from the sun. These particles can be between 100-200 nanometers and sometimes even smaller at less than 100 nanometers. TiO2 particles are located on the surface of the skin and reflect ultraviolet rays. This physical barrier keeps the harmful rays from reaching the skin, so it reduces concerns about the skin penetration of TiO2. Measures include adding additional chemical or physical filters to the formulation, homogenizing the mixture until the smallest TiO2 particle size is reached, and applying large dosages of TiO2 to maximize the product's protection against UVA and UVB rays [16]. However, TiO2 nanoparticles can be toxic to fish and other marine life, so if people want to find sunscreen suits for beach or ocean days, it’s important to choose products that use non-nano TiO2 and avoid harmful additives that can damage marine ecosystems.

3.3. Polymeric nanoparticles

In the cosmetics industry, the uses of polymers are being studied in depth, and a considerable number of patents have been applied for using them to enhance the skin cell activation energy and make the skin more elastic [15]. Polymers always are used as thickeners, and in the cosmetic and personal care industry, they play an important role. In addition to influencing the formulation's rheological profile, they also have an impact on the product's applicability, water sensitivity, and active ingredient delivery. For example, Polyolefin-Diphenylamine, a new method of making antioxidants more soluble and utilising these polymers as lubricants is which is a unique synthesis of antioxidants attached to polymers using an ionic liquid catalyst. It can use this antioxidant for hair care. UV rays have the ability to photodegrade proteins, including cysteine, tyrosine, and tryptophan, as well as bleach the natural melanin in the hair. Both the cuticle and hair colour are impacted by this injury.

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By shielding hair from environmental, mechanical, and chemical harm, a hair conditioner can improve manageability, minimise fly-away, increase volume, improve tactile qualities like dry and wet combing and feel, and improve lustre or shine.

3.4. Liposomes

The medicine is captured by liposomes, which then release the active ingredients in a regulated manner. Liposomes' primary component is phosphatidylcholine, which is also used to make a variety of skincare products, including moisturisers and lotions. Liposomes are employed in a variety of cosmeceutical products due to their biodegradable, less toxic, and biocompatible nature. Additionally, they are used in lotions, moisturisers, sun protection creams, anti-ageing creams, and serums. They also aid in the treatment of hair loss [17]. Liposomes, for instance, are based on water lip care products that enhance the condition of the lips. Almost three times as much water evaporates from the lip surface as from other parts of the skin. Lip motions are more frequent than those of other facial components, and lip wrinkles or lines are much deeper. The substance's solubility feature will indicate its location due to its biphasic nature, which aids in maintaining hydrophilic, amphiphilic, and lipophilic molecules in its structure. Hydrophilic agents are embedded in the aqueous centre or the external aquatic phase, while general, lipophilic and amphiphilic chemicals settle in the liposome's lipid bilayer. This arrangement reduces material loss during storage [17].

3.5. Nanoemulsion

The aqueous formula of nanoemulsion does not require a lot of oil like other moisturisers, which can reduce acne on the skin, so this is one of the excellent choices for oily skin. Nanoemulsions are also can quench thirsty skin in hot and humid climates without the greasy feeling that can accompany traditional creams and face oils. With nanoemulsions, you may increase your hydration without worrying about product buildup. Rich creams are usually applied exclusively at night because traditional creams, which are opaque and rest on top of the skin, improve the skin barrier, but they can feel greasy to those who are prone to acne and oiliness. Due to its lightweight nature and distinctive milky gel-like consistency, nanoemulsions can be used easily day or night on all skin types. This gives emulsions a significant edge over conventional creams since they let the skin absorb moisture without feeling heavy. Additionally, whereas creams tend to stay on the skin's surface, nanoemulsions penetrate better and supply nutrients to the skin's deeper layers. In contrast, not all nanoemulsions provide the same benefits to the skin. People should determine the quality of their skin and make specific emulsions to protect the skin. It is important to make sure the active ingredients in an emulsion are suitable for skin goals [18].

4. Fullerenes

Another nanoparticle that can scavenge free radicals as an antioxidant is Fullerenes. One method to slow down wrinkles and pigmentation is to utilise antioxidants to remove free radicals, which are linked to many skin disorders like rosacea, eczema, and acne. Free radicals are also one of the main drivers of ageing and cancer, but they cannot react with skin and cause harm because the double bonds in the fullerene readily react with them. Fullerene is a fantastic ingredient for skincare treatments that lay around for months or years while being used up since it is stable to heat and light, unlike many other antioxidants like vitamin C. Fullerene is more reactive to free radicals due to its spherical form and unlike many other antioxidants, it retains its antioxidant properties after reacting. According to studies, using a cream with 1% fullerene twice daily for two months reduced acne without compromising the skin's moisture content or barrier function because fullerene can lessen sebum production and pus buildup [18]. The unique applications of fullerenes are due to the

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extraordinary structure of fullerenes, but the cost and availability are high. Therefore, they worked on a tiny scale.

5. Conclusion

Nanotechnology is widely used in the beauty industry, and it has great influence and potential. Today, many cosmetics and skin care products cannot develop without nanoparticles. This essay clearly shows the type and function of nanoparticles and the applications of nanoparticles in the beauty industry. Various nanoparticles, including gold and silver nanoparticles, TiO2 nanoparticles, polymeric nanoparticles, liposomes, nanoemulsions, and fullerenes, have different functions and uses and can overcome the drawbacks of traditional cosmetics and skin products. Some nanoparticles contain special structures that can be used as antioxidants to scavenge free radicals and slow down the visible signs of ageing; some nanoparticles as a suitable filter that can reflect the UV rays that help people prevent the damage of sun; some can treat hair loss and improve the touch of the hair. However, there are many challenges when nanotechnology is practised in these products, and issues such as high cost, people concern nanoparticles are unsafety for skin and so on exist. This review only mentions a small part of it. In addition, these ingredients are not suitable for everyone. Therefore, it is necessary to develop nanotechnology on a large scale and minimize the negative consequences of the nanoparticles used in cosmetics. The firms and researchers need to innovate new skin care products and cosmetics for different types of skin.

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