

Progress in the Application of Nanoparticles in Skin Care Products

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Abstract: The skin care sector has experienced substantial changes due to the rapid advancement of nanotechnology, which has encouraged the development of practical and creative products, particularly in delivery methods. This article systematically examines nanoparticles' progress in skin care products, relying on their classification, valuable features, and current software status. In addition, it examines the distinctive characteristics and benefits of skincare using lipid and healthy nanoparticles. This article examines the impact of nanoparticles on cosmetics, mainly white and skin care products, and their outstanding ability to increase active components' absorption, stability, and bioavailability. The use of nanoparticles opens up new avenues for enhancing the effectiveness of conventional white materials. However, it has much potential for various skin care needs, including polyphenols, soothing, and anti-ageing. However, its app also has issues with safety, stability, and long-term effects. Additionally, the essay makes related optimization recommendations. Balancing efficiency, safety, and comfort has become a crucial research topic as the demand for white skin care products rises.

Keywords: Organic nanoparticles, skin care products, chemical engineering.

1. Introduction

With the increasing demand for whitening skin care products in modern society, how to ensure the safety, comfort and long-term performance of products while ensuring the whitening effect has become an important research direction in the current skincare field. As an emerging technology, nanotechnology has been widely used in various skin care products, especially in the field of whitening skin care, and has attracted much attention because of its unique advantages and potential.

Because of their small size, large surface area, and high biocompatibility, nanoparticles show significant advantages in improving the permeability, stability, and bioavailability of active ingredients. Especially in whitening skin care products, the application of nanoparticles provides new possibilities for breakthroughs in traditional whitening ingredients, which can effectively improve their effectiveness and reduce skin irritation. With the deepening of research, the application of nanoparticles in whitening skin care has shown a diversified trend, not only including the delivery of whitening active ingredients but also involving multiple skin care effects such as anti-aging, moisturizing, and antioxidants.

Nanoparticles, due to their small size and unique properties, provide many advantages for skincare formulations, including improved penetration, enhanced stability, and targeted delivery of active

ingredients. This article aims to comprehensively review the application progress of nanoparticles in skincare products.

2. Classification of nanoparticles

2.1. Natural nanoparticles

Natural nanoparticles refer to nano-sized particles extracted from natural substances, such as plant extracts, minerals, etc. The advantage of natural nanoparticles is their natural origin and good biocompatibility, which can reduce irritation to the skin while having certain antioxidant, anti-inflammatory, and whitening effects. Common natural nanoparticles include plant polysaccharide nanoparticles, resveratrol nanoparticles, vegetable oil nanoparticles and so on.

The basic principle of natural nanoparticles is to improve skin permeability and bioavailability by Nanoparticles natural extracts to reduce their particle size to between 10-100 nanometers. For example, resveratrol nanoparticles can achieve whitening effects by penetrating the surface of the skin and reaching the deeper layers of the skin, exerting antioxidant and anti-inflammatory effects.

The preparation methods of synthetic polymer nanoparticles mainly include mechanical crushing, solvent-non-solvent method, salting-out method, in addition, the emulsification diffusion method, emulsification-solvent volatilization method and interfacial polymerization method are also commonly used for the preparation of synthetic polymer nanoparticles [1]. Mechanical pulverization method refers to the use of specific machinery to directly crush substances into nanoscale particles, mainly including high pressure homogenization-air pocket blasting method, air crushing method, vibration refining method, etc., the preparation of nano-size range of examples is called ultrafine grinding. This method has the advantages of simple process and is conducive to industrial production. Solvo-non-solvent method adds a liquid (non-solvent) that is insoluble to the polymer solution, thus causing phase separation, and then the shear encapsulation to form nanoparticles gas salting-out method refers to the addition of electrolyte or non-electrolyte saturated Polyvinyl Alcohol (PVA) aqueous solution to the solution containing the polymer and polymer materials under mixing conditions. The O / W type emulsion was prepared by using PVA as the emulsifying stabilizer, and then sufficient water was added, so that the fine water was diffused into the water phase to form nanoparticles through induction.

2.2. Lipid nanoparticles

Lipid nanoparticles, including liposomes and solid lipid nanoparticles, are nanoparticles composed of lipid molecules and other materials. The advantage of lipid nanoparticles is their good encapsulation and stability, which can effectively encapsulate and deliver both water-soluble and oil-soluble active ingredients, avoiding the failure or degradation of active ingredients in the product.

The basic principle of lipid nanoparticles is to enhance the stability and permeability of substances through their nanoscale particle size, and at the same time, liposomes can promote the repair of the skin barrier and improve the skin's adaptability to the external environment. In whitening skin care, lipid nanoparticles can effectively deliver active ingredients with whitening effects, such as vitamin C, arbutin, etc., to achieve whitening effects.

The preparation methods of natural polymer nanoparticles mainly include emulsion polymerization, molecular self-assembly and ion crosslinking. The microemulsion solution was prepared by using surfactants and two kinds of insoluble solvents. The nanoparticles were formed after nucleation and agglomeration heat treatment in the microemulsion droplet. The mechanism of this method is mainly oligomer nucleation and latex nucleation, which belongs to a discontinuous nucleation process, that is, the number of colloidal particles does not change in the growth stage of latex particles, and the particle disease keeps growing. The emulsion polymerization method is

suitable for substances with large solubility in acidic media. Molecular self-assembly method refers to the self-agglutination process of hydrophobic modified water-soluble polysaccharide obtained by simulating macromolecular interaction in organisms. The ion crosslinking method uses the interaction between opposite charges to produce a physical electrostatic crosslinking reaction, thus forming a beaded gel nanoparticle. A large number of amino groups in the structure of chitosan can be protonated to form a polycationic electrolyte in the acidic medium. Therefore, the electrostatic interaction between the amino cations in the structure of chitosan and other electronegative molecules (such as tripolyphosphate, polyglutamic acid, etc.) can be used to prepare nanoparticles. The ion crosslinking method not only has the advantages of mild reaction conditions, simple preparation process and small damage to natural components, but also the obtained nanoparticles are uniform in size, can be designed, and can avoid the use of organic crosslinking agents. This method has become the most promising method for the preparation of natural polymer nanoparticles.

3. Application status

3.1. Nanoparticles in cosmetic applications

Nanoparticles (NP) are bioactive substances, including Nanospheres and Nanocapsules, with diameters ranging from 1 to 1000nm. When the particles enter the nano level, due to the small size effect, surface effect, macro quantum tunneling effect, etc., the nanoparticles will show a series of new characteristics different from macro substances, such as low melting point, high reactivity, high expansion coefficient, high strength, high toughness, high diffusivity, and strong absorption rate. It is precisely because of these properties that nanoparticles have become a hot spot in the applied research of cosmetics, medicine, functional food and other fields.

Whitening cosmetics refer to cosmetics that help reduce or slow down skin pigmentation to achieve skin whitening and brightening effects. With the increasing demand for whitening cosmetics, the number of cosmetics and ingredients claiming to have whitening effects is growing day by day. However, in the increasingly fierce market competition, there are constantly false advertising slogans claiming that products have whitening effects such as "inhibiting melanin" and "fading pigmentation", misleading consumers to make purchases. Under relevant policy regulations, the evaluation and supervision of cosmetic whitening effects have been tightened. Currently, whether the whitening ingredients in cosmetics can effectively reduce melanin formation is the key to testing whether cosmetics have whitening effects. The amount of melanin content determines the depth of color of human skin, eyes, hair, and other tissues, and is also related to skin homeostasis. Abnormal levels of melanin can trigger skin diseases caused by pigment disorders, such as vitiligo, melasma, and uneven skin tone. More seriously, it can also lead to skin cancer, such as melanoma. According to research by the National Cancer Institute in the United States, melanoma is the deadliest skin cancer. Therefore, research on whitening is not only aimed at achieving visually fair skin but more importantly, at preventing and treating various skin diseases caused by abnormal levels of melanin. The currently recognized pathway for melanin formation is the one proposed by Raper Mason, which involves the hydroxylation of tyrosine to form dopamine (DA) under the catalysis of tyrosinase (TYR). Subsequently, TYR further oxidizes DA to dopaquinone (DQ), which rapidly and spontaneously develops towards the formation of various melanocytes, forming 5,6-dihydroxyindole (DHI) and 5,6-dihydroxyindole-2-carboxylic acid (DHICA). Oligomers composed of these monomers are called true melanin, and the depth of skin color is mainly determined by them. In addition, DQ can also form melanin through oxidation of glutathione or cysteine. The formation mechanism of true melanin and brown melanin is mainly related to the activity of TYR. High activity TYR leads to the formation of true melanin, while low activity TYR leads to the formation of brown melanin. The mechanism of melanin formation is complex, and in addition to TYR controlling melanin formation, oxidative stress

response also plays a key role in the process of melanin formation. Applegate et al. simulated the expression of ferritin in cells after solar radiation and confirmed that ferritin mainly binds to trivalent iron. The expression level of ferritin can be used as a marker of oxidative stress response and applied to the efficacy evaluation of sunscreen. Maresca et al. analyzed TYR activity in melanocytes and control cells after downregulation of ferritin using enzyme-linked immunosorbent assay. The experimental results showed that the TYR activity of melanocytes was significantly reduced after downregulation of ferritin, thus confirming that downregulation of ferritin can inhibit TYR activity and thus inhibit the formation of melanin. Wan et al. measured the intracellular melanin content, TYR activity, and ferritin levels, and the results showed that the downregulation of ferritin was consistent with the decreasing trend of TYR related protein levels necessary for melanin synthesis. This means that ferritin levels may directly affect downstream targets of the melanin production pathway. Meanwhile, abnormal iron metabolism is more pronounced in diseases induced by abnormal melanin synthesis, such as vitiligo. Existing research has revealed that the expression level of ferritin in the epidermis of vitiligo patients is low, thus proving that downregulation of ferritin significantly affects melanin formation.

3.2. Melanin formation pathway and its regulation

The cleaning, protection, nutrition and function of cosmetics on human skin are mainly determined by the various effective ingredients that penetrate or absorb into the skin, and the effectiveness of cosmetics prepared by traditional processes is often difficult to fully play. Moreover, as consumers' functional demands for cosmetics continue to change, from the initial simple care such as moisturizing and moisturizing to the in-depth repair such as sunscreen, whitening and anti-aging, the corresponding cosmetic production technology has developed from the initial simple compounding to the application of a variety of cosmetic functional factors. It also goes into the higher level of how to make effective ingredients fully absorbed by the skin and hair. By using new nanotechnology to treat cosmetics, the effective ingredients in them can be more easily absorbed through the skin, and the efficacy of cosmetics can be greatly improved. The advantages of nano cosmetics are mainly reflected in the following aspects: (1) significantly improve the efficiency of the use of effective ingredients. Studies have shown that if cosmetics contain nano-level cinnamon spot components, infiltration into the skin will become very smooth, absorption effect has been greatly improved; (2) Improve the antibacterial and bacteriostatic effects of skin. Nanoscale particles can interfere with the synthesis of bacterial proteins and effectively inhibit bacterial reproduction, thus promoting immune regulation of the skin. (3) Enhance the sunscreen effect. In sunscreens, iron dioxide and zinc oxide are widely used UV reflectors, but their brightening properties limit their use. Nanotechnology can reduce the particle size of raw materials to nanometers, so this problem is technically solved. In addition, nano cosmetics can also improve the stability of active components, reduce irritation, improve the appearance of products, cover up undesirable odors, etc.

At present, the whitening factors widely used in the market mainly include hydroquinone, kojic acid and its derivatives, β -arbutin, etc. Among them, the synthetic β -arbutin has the advantages of high purity, light color and high activity, and occupies a dominant position in the market. However, some studies have shown that β -arbutin is easily hydrolyzed to strongly allergenic hydroquinone under weak acidic conditions, so it is speculated that β -arbutin entering the human body may be hydrolyzed and damage the skin. Therefore, the safety of β -arbutin as a whitening factor has been questioned, and the search for a safer and more efficient whitening agent has become the focus of attention in the whitening cosmetics industry.

3.3. Progress of nanoparticles in whitening products

Nano titanium dioxide is widely used in biomedical fields, such as beauty care products, killing cancer cells, as antibacterial agents, etc. Nano TiO₂ is a kind of wide-band gap semiconductor material, and can also be used as a photocatalytic material. As a photocatalytic material, titanium dioxide has the advantages of low price, environmental protection and durability, high stability, non-volatilization, etc., but because of its large band gap, the utilization rate of visible light is very low, which is its obvious disadvantage as a photocatalyst. In recent years, people have tried a variety of methods to improve the utilization of titanium dioxide to visible light, including metal doping, non-metallic doping, transition metal doping, or two elements co-doping, etc., by improving the energy band structure of titanium dioxide to improve its utilization of visible light. As an energy conversion and storage device, nanocrystalline core-shell structures are widely used in various fields such as catalysis. It was found that the surface of nano-titanium dioxide particles was coated and modified by polydopamine to form nano-core-shell structure, which changed the properties of nano-titanium dioxide, including photocatalytic properties. It can effectively improve the photocatalytic reaction efficiency of the material in the visible light range. At the same time, when nano-titania polydopamine is excited and interacts with water in the visible blue-violet light range, a large number of ROS, namely superoxide ion free radicals and hydroxyl free radicals, can be generated, which has strong oxidation ability and can effectively decompose pigments. On this basis, polydopamine modified nano titanium dioxide can be used in the field of tooth whitening. In addition, titanium dioxide itself is an inorganic antibacterial agent, which has a broad spectrum antibacterial effect on a variety of bacteria.

Wang, et al. found that BLFN showed mass concentration-dependent inhibition on tyrosinase activity, melanin synthesis and cell proliferation in B16 cells. When the mass concentration of BLFN was 100 mg/L, the inhibition rates reached 69.68%, 62.35% and 59.14%, respectively. Both were significantly better than β -arbutin ($p < 0.05$, p is a statistical indicator of difference, $p < 0.05$ means statistically significant). The results of in vitro experiments on B16 cells showed that BLFN could play a whitening effect by inhibiting melanocyte activity, tyrosinase activity and melanin synthesis, which showed the potential of replacing β -arbutin. At the same time, because the construction components of the nanoparticle are all natural substances, it has high safety.

Fatemeh et al. studied an eye patch based on PVA-gelatin nanocomposite nanofibers for rapid delivery of Coenzyme Q10 anti-aging agents. Through in vitro and in vivo experiments, they found that the patch was able to significantly improve the skin permeability and bioavailability of coenzyme Q10, thus effectively slowing the skin aging process [2]. This research provides a new strategy for developing effective anti-aging skin care products. Eliana et al. focused on the use of anti-aging peptides in advanced skin care products and focused on the role of nano delivery systems [3]. They noted that the nano delivery system was able to significantly improve the stability and skin permeability of the anti-aging peptides, thereby enhancing their anti-aging effects. In addition, the nano delivery system can also achieve the targeted delivery of anti-aging peptides, improving the pertinence and effectiveness of skin care products.

Ruo et al. studied the formulation and performance evaluation of solid lipid nanoparticles containing Kappaphycusalvarezii extract in cosmetic gels [4]. They found that the solid lipid nanoparticles were able to significantly improve the extract's stability and skin permeability, thereby enhancing its skin care effects. This research provides a new technical way to develop skin care products containing natural ingredients. Xiang et al. reported a synthesis method of acyl quercetin selenate nanoparticles and discussed its potential application in skin care products [5]. They found that the nanoparticle has excellent antioxidant and anti-aging properties, which can significantly improve the elasticity and gloss of the skin. This study provides a new way to develop skin care

products containing selenium. El 'e bieta et al. reviewed the synthesis methods of silver nanoparticles and their applications in skin care products [6]. They pointed out that silver nanoparticles have excellent antibacterial properties and skin permeability, which can significantly improve the antibacterial effect of skin care products and skin health level. However, the cytotoxicity and skin safety of silver nanoparticles still need to be further studied and evaluated.

4. Problems and optimizations

Although improvements have been made with the use of nanoparticles in skin-whitening materials, some issues need consideration. Health, security, and production processes in the skin treatment sector also require thorough investigation and refinement despite the modern breakthroughs made by nanotechnology.

4.1. Problems

Many useful cosmetic products currently require more components and better transdermal intake. Co-transportCo-transport nanocarriers, which may carry many white agents together, offer a solution by achieving a simultaneous effect among several skincare ingredients. However, you must address the following issues:

4.1.1. Long-term safety concerns

Concerns about the long-term protection of nanoparticles have been raised by their smaller size and substantial specific surface places. According to research, specific nanoparticles, such as metal oxide and titanium dioxide, may pass through skin pores, likely affecting human health, especially those exposed for a long time. Although most nanoparticles are generally accepted as safe, some studies suggest that they may collect on the skin, causing harm to body tissues and cells, raising the risk of allergic reactions, and [7] affecting the skin barrier's ability. Thus, a thorough analysis of their long-term bioaccumulative effects and possible skin damage is required.

4.1.2. Skin irritation and allergic reactions

Some nanotechnology may cause allergic reactions or skin pain, but nanoparticles improve the effectiveness of skin care ingredients by enhancing their deposition and diffusion on the skin surface. People with sensitive skin are especially vulnerable to nanoparticles made of particular metals (such as aluminium and silver), which can cause dryness, itching, or other sensitive reactions [8]. Specific nanoparticles with chemical coatings may also impair the body's natural barrier, causing dryness, peeling, and inflammatory responses. Therefore, future research requires careful design and selection of skin-friendly nanoparticles that do not cause allergic reactions.

4.1.3. Potential effect on skin barrier function

The skin challenge is the body's second line of defence against harmful substances. Nanoparticles can increase skincare ingredient absorption and make the white influence more effective, but their effects on the skin barrier need further investigation [9]. Specific nanoparticles may impair the body's natural cholesterol level, causing water damage and decreased protection. The skin may become dry and delicate and age more quickly. Additionally, excessively porous nanoparticles may strip skin of water, leading to prolonged dryness and more skin issues. In order to design nanoparticles, their effects on the skin barrier may be considered appropriately to prevent them from compromising the skin's self-repairing system.

4.2. Countermeasures

4.2.1. Production cost reduction

Graphene production processes rely on chemical synthesis, natural evaporation, or solution methods, which are expensive, time-consuming, and pose ecological or safety risks. Researchers are looking into more cost-effective and affordable manufacturing techniques to reduce expenses. For example, using plant extract or pathogens as reducing agents to create nanoparticles lowers costs and lessens environmental pollution. The use of nanoparticles in white skin care products can become more common by accelerating production, increasing productivity, and reducing waste from raw materials [10].

4.2.2. Production and standardization on a large scale

Mass production in conventional nanoparticle production can be complex, resulting in product consistency and process volatility. In order to improve output balance and reduce costs, it is crucial to promote large-scale production and establish uniform production procedures. Creating nanoparticles more competitive in the market for cleaning beauty provides solution consistency and lowers the cost per unit through mass production [11].

4.2.3. Creation of biodegradable nanoparticles

Some nanoparticles accumulate on the body after usage or even entering the body, potentially putting both human health and the environment at risk. Future studies may concentrate on creating biodegradable nanoparticles to solve this [12]. These particles typically degrade over time after being applied to the skin, reducing the chance of long-term formation in the body. Experts can create environmentally friendly alternatives to replace conventional non-degradable nanoparticles with biodegradable nanocarrier elements like natural polymers and proteins.

5. Conclusion

According to the thorough study conducted in this report, it is clear that using nanoparticles in skin care products has both probable advantages and drawbacks. The research examines the safety concerns and manufacturing viability of these contaminants and their potential benefits for enhancing skin whitening results.

In terms of research findings, the application of nanoparticles, especially titanium dioxide and zinc oxide, has shown promising results in increasing skin whitening performance due to their ability to disperse and collect UV radiation, thus reducing melanin production. Safety concerns persist as a significant problem despite the incomplete understanding of the long-term effects of particle exposure on epidermis health. However, the production cost of nanoparticles and their skin permeability need to be addressed to boost their commercial viability.

In summary, while using nanoparticles in skin care products may help improve skin appearance, more research is required to address the abovementioned issues. Future research should concentrate on enhancing the skin-friendly and degradability of nanoparticles and adjusting their manufacturing processes to lower costs and increase skin permeability.

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