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Review Article

Nanotechnologies In Cosmetics. A Review

Pranali Ganraj*[1], Vishal Gaikwad[2], Vaibhav. A. Jadhav[2]

*[1]*Author Student at Pratibhatai Pawar College of Pharmacy,*
[2]*Assistant Professor at Pratibhatai Pawar of Pharmacy*

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ABSTRACT

Today, nanotechnology is widely utilized across various industries, ranging from molecular biology to electronics, textiles to food, and beyond. Within the cosmetics sector, this emerging trend has been extensively adopted by manufacturers to enhance their existing products and develop new ones. Nanomaterials are employed to offer improved UV protection, deeper skin penetration, longer-lasting effects, enhanced color and finish quality, and more. Inorganic nanoparticles like TiO2 and ZnO are commonly utilized as UV filters in sunscreens. Additionally, cosmetics and personal care products incorporate various encapsulation and delivery systems such as liposomes, niosomes, dendrimers, nanoemulsions, and solid lipid nanoparticles. This comprehensive review article presents valuable insights into the types of nanomaterials employed in cosmetic products, as well as the potential benefits and risks associated with their usage.

INTRODUCTION

Nanotechnology encompasses a wide range of scientific disciplines, including chemistry, physics, electronics, biology, materials science, and engineering. As an interdisciplinary subject, it brings together these fields to explore the potential applications that arise from their convergence. These applications span a diverse range, from the development of advanced tennis rackets to the creation of innovative medicines and entirely new energy systems. At its core, nanotechnology revolves around the manipulation and understanding of extremely small entities. A nanometre, which is one billionth of a meter, represents the scale at which these entities operate. To put it into perspective, a nanometre is approximately 80,000 times smaller than the width of a human hair. Particles within the nanometre range, known as nanoparticles, exhibit distinct properties compared to their larger counterparts. This is due to their relatively larger surface area in relation to their mass, allowing for increased chemical reactivity and interactions with atoms at the surface. (1,2) Nanoscale materials have been utilized for several decades and have found diverse applications. They have been employed in the

***Corresponding Author:** Pranali Ganraj
Address: *Author Student at Pratibhatai Pawar College of Pharmacy*
Email : pranaliganraj197@gmail.com

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production of window glass, sunglasses, and paints. In recent times, nanotechnology has expanded its reach to encompass the manufacturing of materials, electronic chips, medical diagnosis and healthcare, energy production, biotechnology, space exploration, security systems, textiles, and sports equipment, among others. The advancement of nanotechnology also presents opportunities for the cosmetic industry to develop novel biocompatible and biodegradable therapeutics, delivery systems, and more potent compounds. In today's society, an increasing number of individuals, including both women and men, are utilizing cosmetics to enhance their physical appearance. Consequently, cosmetic manufacturers have endeavoured to create a wide array of modern cosmetic products that incorporate nano-sized components. The integration of nanoparticles in these products is believed to enhance their performance and overall quality. (3)

Leading brands of Nanocosmetics:

Various surveys have revealed that nearly all prominent cosmetic manufacturers incorporate nanotechnology into their diverse product lines. In 2006, Estee Lauder, a renowned cosmetics giant, ventured into the Nonmarket by introducing a range of products infused with "Nanoparticles." L'Oreal, the largest cosmetics company globally, has allocated approximately $600 million dollars from its $17 billion dollar revenues towards Nano patents. Moreover, L'Oreal has secured patents for the utilization of numerous "nano some particles" and currently holds the sixth position among nanotech patent holders in the United States. (3) Additional instances comprise of Freeze 24/7, DDF (Doctor's Dermatologic Formula), and Colorescience. (4)

There is a wide range of nanomaterials that are employed in the field of cosmetics:

Liposomes:

The product known as cream capture, which was created by company Dior in 1986, is composed of liposomes. Liposomes are formed by a lipid bilayer, and despite their instability and the addition of anti-oxidants, they have found utility in the field of cosmetics. (5,6) Liposomes were the pioneering class of Nano-carriers developed in the early 1970s for drug delivery systems. These biocompatible, biodegradable, non-hazardous, and flexible vesicles have the capacity to easily encapsulate active ingredients, making them suitable for delivering both hydrophobic and hydrophilic compounds. (7) Moreover, liposomes possess the ability to enhance the absorption of active ingredients by the skin, thereby increasing their concentration. (9)

Nano emulsions:

Nano emulsions are characterized by the presence of nanoscale droplets of one liquid dispersed within another liquid. (10) These systems are considered metastable, meaning that their structure can be altered depending on the method of preparation. The components utilized in the production of nano emulsions are generally recognized as safe (GRAS) products, ensuring their safety for use. The smaller particle size of these emulsions contributes to enhanced stability and improved capacity to transport active ingredients. Additionally, the incorporation of nanoscale droplets extends the shelf life of the product. (11,12)

Nano Capsules:

Nanocapsules, which consist of a polymeric capsule enclosing either an aqueous or oily core, are minute particles at the sub microscopic level. Recent studies have demonstrated that the utilization of nanocapsules leads to a reduction in the permeation of the UV filter octyl methoxycinnamate into pig skin, as compared to conventional emulsions. This finding highlights the potential of nanocapsules in enhancing the efficacy of skincare products. (13)

Nanocrystals:

On the other hand, nanocrystals are aggregates formed by the combination of several hundred to tens of thousands of atoms, resulting in a "cluster" structure. These aggregates typically range in size from 10 to 400 nm and possess physical and chemical properties that lie between those of bulk solids and individual molecules. Notably, nanocrystals offer a safe and efficient means of penetrating the skin barrier, thereby enabling the delivery of therapeutic agents or active ingredients for various applications in dermatology and cosmetics. (14)

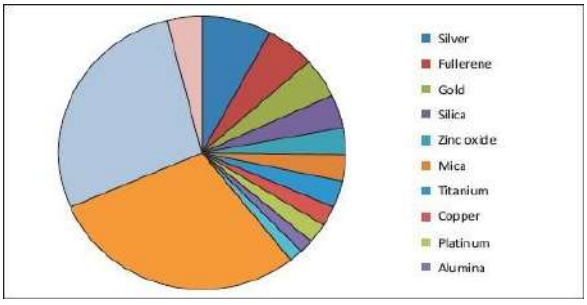
Dendrimers:

Dendrimers exhibit a symmetrical, regularly branched structure and possess a high density of functional end groups at their periphery. These unimolecular, monodisperse, micellar nanostructures are approximately 20 nm in size and offer a multitude of external groups that can be utilized for Multi functionalization. (15.16)

Hydrogels:

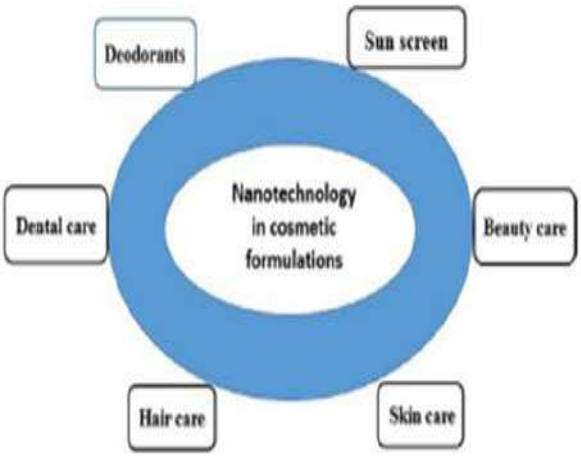
Hydrogels are polymer networks that exhibit hydrophilic properties and expand in water or biological fluids due to chemical or physical cross-links. These 3D structures possess the ability to anticipate forthcoming alterations and adapt their characteristics to mitigate potential harm. (17)

Principle Nanomaterials used in Various Cosmetics18:



APPLICATIONS OF NANOMATERIALS IN COSMETICS AND DERMATOLOGY:

Schematic diagram showing the different applications of nanotechnology in cosmetic formulations and their valuable cosmetic effects as modified from Morais et al.



Nano Sunscreens:

Nanoparticles offer significant advantages in terms of Ultraviolet (UV) protection due to their small size. In order to create sunscreen that is transparent rather than white, UV filters such as titanium dioxide and zinc oxides have been utilized in micro/nano form. These physical sunscreens effectively block both type A and B UV radiations. However, there are certain limitations associated with these formulations, such as the requirement of a greasy vehicle for dissolution, leaving behind chalky white residues on the skin, and having a thick and dense consistency (19). At the nanoscale, the composition of these particles' changes, rendering them invisible and therefore more aesthetically pleasing. Nanoparticles composed of compounds like titanium dioxide and zinc oxide have the ability to reflect, absorb, or disperse UV radiation. Recently, safranal -loaded solid lipid nanoparticles were developed, which exhibited enhanced sun screening activity within the size range of 103-230 nm (20). These solid lipid nanoparticles were formulated to synergistically improve sun protection (21).

Nanotechnology in Protective Creams:

The protective function of the outermost layer of the skin, known as the stratum corneum, may not be sufficient in shielding the skin from specific irritants like chemotherapeutics, allergens, or dermatitis. However, the use of barrier creams containing nanoparticles proves to be more effective in safeguarding the skin from moisture loss. Consequently, this reduces the potential risk of developing irritant hand eczema compared to moisturizers that have a high lipid content (22,23).

Nanocosmetics In Treating Acne:

Solid lipid nanoparticles containing neem oil have demonstrated a prolonged effect and exhibited antibacterial properties against acne-causing microbes for a duration of 24 hours. (24) Nano Cyclic Inc. specializes in the production of Nano Cyclic cleanser pink soap, a meticulously formulated combination of nanosilver and natural components. This product asserts its ability to eliminate harmful bacteria and fungi, combat acne, and reduce the appearance of age spots and sun-damaged skin. (25)

Nano moisturizer:

Nano moisturizers play a crucial role in treating various skin conditions like eczema, psoriasis, pruritus, and aging skin. These conditions are characterized by reduced levels of ceramide and altered ceramide profiles in the skin. Traditional emollients have limitations in effectively delivering active ingredients. On the other hand, nano-emulsions are advanced colloidal drug carrier systems that can effectively restore ceramides in diseased skin, particularly in cases of atopic dermatitis. (26) The use of Opuntia Ficus-indica extract nano-emulsions has shown improved moisturizing effects. Additionally, liposomes containing N-acetyl glucosamine and glucosamine have been developed to enhance the localization of active ingredients in the skin and maintain skin hydration and elasticity. (27,28)

Nanotechnology in Anti-aging Formulations:

The process of aging significantly impacts the physical characteristics of skin collagen, leading to a variety of undesirable effects including reduced oil production, dryness, texture loss, age spots, and sagging skin. As a result, wrinkles form due to the thinning of the skin. In a study, it was found that biocompatible nano-lipoidal carriers containing isotretinoin exhibited enhanced photo-aging properties, improved compatibility with the skin, and potential anti-aging effects (29). Additionally, solid lipid nanoparticles containing soy isoflavones demonstrated superior penetration through the outermost layer of the skin, known as the stratum corneum, and efficient deposition of soy isoflavones within the dermal matrix (30).

Nanomaterials in antiseptics:

Antiseptics have seen advancements with the introduction of nanomaterials, with various substances being utilized in nano-formulations. Examples of these substances include Chlorhexidine gluconate, naked TiO2, and silver. Notably, chlorhexidine gluconate and silver have been incorporated into nano-formulations to enhance their antiseptic properties. For instance, a chlorhexidine-loaded polymeric nanocapsule was developed using the interfacial deposition method, resulting in superior antimicrobial activity. Additionally, solid lipid nanoparticles containing silver exhibited improved antiseptic activity.

CONCLUSION

This review highlights the significance of nanotechnology as a revolutionary force in the industrial sector, particularly in the field of dermatology and cosmetics. Nanotechnology offers a wide range of therapeutic, diagnostic, and preventive applications in these areas. As one of the key technologies of the twenty-first century, it presents promising opportunities for scientists and the pharmaceutical industry alike. However, current research is primarily focused on developing biodegradable nanomaterials to

address concerns related to toxicity and the environment, thereby enhancing safety. Furthermore, it is crucial to note that the nanomaterials currently used in cosmetic preparations and sunscreens have been proven to be safe for human skin and health. To ensure the well-being of manufacturers, regulatory authorities, and consumers, it is imperative to establish international harmonization in terms of product safety and evaluation..

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