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A Review on the Synthesis of Zinc Oxide Nanoparticles by Green-Tech Approach for Applications in Cosmetics Dermatology

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Abstract

Investigating zinc oxide nanoparticles (ZnO NPs) and their biological manufacturing techniques has been fueled by the cosmetics industry's search for novel and sustainable solutions. This thorough analysis explores the changing field of ZnO NPs, emphasizing their biological production and several cosmetic uses. After providing some background information on the limits of conventional chemical synthesis, we explore the wide range of biological agents—such as bacteria, fungi, and plants—that are used to synthesize ZnO NP. The distinct physicochemical characteristics of organically manufactured ZnO NPs are revealed by characterization approaches, demonstrating their potential benefits over their conventionally produced counterparts. Understanding the effectiveness of these nanoparticles in cosmetic formulations is made possible by the ensuing investigation of their characteristics. ZnO NPs are used in sunscreens, skincare products, and other formulations in the cosmetics industry; their biological production gives them unique properties. The responsible incorporation of these nanoparticles into cosmetic products is discussed, along with safety and regulatory issues. The review provides a roadmap for furthering research in biological synthesis techniques and cosmetic applications by identifying present issues and speculating about future approaches. Successful uses are demonstrated by case studies, which provide a concrete viewpoint on incorporating biologically produced ZnO NPs into cosmetic formulations. In summary, this analysis highlights the critical role that ZnO NPs will play in determining the direction of the cosmetics sector and compiles the most recent developments in their biological synthesis. Researchers, industry professionals, and regulatory bodies can benefit greatly from this paper's comprehensive approach, which covers synthesis mechanisms, characterization, applications, safety issues, and prospects.

Keywords: *ZnO NPs*, *Nanotechnology*, *Green synthesis*, *Dermatology*, *Skincare.*

INTRODUCTION

The scientific field that studies nanoparticles with dimensions between ten and hundred nm is called nanotechnology. Nanobiotechnology is an interdisciplinary discipline that uses nanotechnology for biotechnological applications. There are numerous uses for this new sector in the pharmaceutical, cosmetic, and food industries. Nanotechnology has created a range of novel nanomaterials to enhance agricultural development, environmental monitoring, and food quality and safety (1). Over the past ten years, the prefix Nano has been used more and more in several disciplines of expertise. Among the new Nano-containing phrases that are commonly used in scientific publications, popular literature, and newspapers and that the general public, including non-experts, is now familiar with are nanoscience, nanotechnology, nanomaterials, and Nanochemistry (2). Within the convention of the International System of Units (SI), it is used to indicate

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a reduction factor of 10^9 times. Zinc oxide nanoparticles (ZnO NPs) in particular have attracted a lot of attention because of their special qualities and numerous uses in skincare products (3). Synthesis processes have undergone a paradigm shift in recent years, shifting toward environmentally benign and sustainable practices. The pressing demand for green technologies that reduce their negative effects on the environment and guarantee customer safety is what is causing this change. Green synthesis techniques that use natural resources and reducing agents instead of dangerous chemicals have become viable ways to produce ZnO NPs (4). This paper examines the most recent developments in the green-tech manufacturing of zinc oxide nanoparticles and their uses in dermatology and cosmetics (5). This review seeks to provide insight into the sustainable future of cosmetic nanotechnology by exploring the nuances of green synthesis methods and how they affect skincare formulas (6). This review seeks to provide insight into the sustainable future of cosmetic nanotechnology by exploring the nuances of green synthesis methods and how they affect skincare formulas.

Challenges and future perspective:

To direct future research efforts, a comprehensive investigation is necessary into the emerging subject of biological production of zinc oxide nanoparticles (ZnO NPs), which offers both unique obstacles and fascinating prospects. Achieving consistent and repeatable synthesis results across many biological agents is one of the main obstacles (7). Different nanoparticle features can be produced by variations in bacterial species, fungal strains, or plant extracts, which calls for a better comprehension of the complex biological processes at play. Furthermore, it is still difficult to scale biological synthesis techniques. Although laboratory synthesis on a small scale has shown promise, applying these techniques to industrial scales presents challenges concerning cost-effectiveness, uniformity, and production efficiency. Another difficulty is safety concerns, particularly when it comes to cosmetic applications. To guarantee consumer safety, the possible toxicity of biological agents or by-products in produced nanoparticles needs to be carefully investigated (8).

Zinc Oxide Nanoparticles:

ZnO NP is a type of metal oxide nanoparticle that has garnered a lot of attention because of its unique catalytic, antibacterial, antifungal, photochemical, UV-filtering, and anti-inflammatory properties due to its large surface area-to-volume ratio. Its structural and empirical formula is ZnO, and its physical form is a solid, white, odorless powder with a molecular weight of 81.38gmol (9). Multipurpose oxide metal nanoparticles and zinc oxide nanoparticles (ZnO-NPs) have special properties such as UV filtering, semiconducting, antibacterial, antifungal, and photo-catalytic activity (10). For biological applications, zinc oxide nanoparticles (ZnO NPs) are a good option since they are safe, non-toxic, biocompatible, easy to produce, and environmentally friendly. In everyday life, zinc oxide (ZnO), an inorganic material, is frequently utilized. Currently, ZnO is being used. A material that is listed as generally regarded as safe (GRAS) (11). The advent of nanotechnology has led to the creation of materials with unique properties for a range of uses. ZnO has thus shown its nanoscale properties as antibacterial compounds. antibacterial properties and potential uses in food preservation ZnO nanoparticles have been incorporated into polymeric matrices to enhance packaging performance and offer antibacterial activity (12). Additionally, ZnO NPs have exceptional UV-blocking, antibacterial, and antimicrobial properties. As a result, finished textiles with ZnO NPs in the textile industry have the desirable qualities of deodorant, antibacterial, and resistance to UV and visible light. In addition to the uses mentioned above, zinc oxide is used in a wide range of sectors, such as photocatalysis, electronics, electrotechnology, and concrete manufacturing. ZnO's potent UV-absorbing qualities have led to its growing application in personal care products including sunscreen and makeup (13).

Synthesis of Zinc Oxide Nanoparticles

Although NPs can be synthesized in several methods, they are often divided into two groups.

Synthesis from the top down:

In this process, the destructive approach is employed. A larger molecule is first broken down into smaller parts, which are then transformed into the proper NPs. This technology includes breakdown methods such as physical vapor deposition (PVD), chemical vapor deposition (CVD), and grinding/milling (14).

Synthesis from the bottom up:

Since NPs are composed of comparatively simple components, this tactic is sometimes referred to as the building-up technique. Procedures for sedation and reduction are two instances of this (15). Included are spinning, biological synthesis, green synthesis, and sol-gel. There are several methods used to synthesize ZnO. The three types of procedures that can be employed are chemical, biological, and physical methods (16).

Physical Method

Physical methods for creating ZnO nanoparticles include high-energy ball milling, melt mixing, physical vapor deposition, laser ablation, sputter deposition, electric arc deposition, and ion implantation (17). ZnO nanoparticles are mostly employed in industrial processes and have relatively high production rates in the majority of physical and mechanical processes. The physical method requires a large space for machine setup, high temperatures and pressures, and costly equipment (18).

Chemical Method

The terms sol and gel are combined to form the term "sol-gel." A colloid composed of solid particles suspended in a continuous liquid is called a sol. A solid macromolecule called gel dissolves in a liquid. Because of its ease of usage, the sol-gel process is the most used bottom-up technique for creating nanoparticles. a suitable chemical solution that acts as a catalyst during a process. In the sol-gel process, metal oxide and chloride are often used precursors (19). In the

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process of creating nanoparticles, capping and reducing agents are essential. Environmental flaws are caused by the use of dangerous and extremely toxic substances in the chemical and physical processes used to create nanoparticles (20). Expensive reducing or capping agents are needed for physical and chemical processes. Chemicals used in physical and chemical processes may be present in the NPs that are created, which could be dangerous when used in the medical area Therefore, we required a cost-effective and environmentally responsible way to synthesize nanoparticles. Therefore, the biological approach is the most desirable strategy for creating nanoparticles (18).

Biological Method:

The process of creating nanoparticles with potential use in medicine by using microorganisms and plants is known as biosynthesis. This approach is ecological, safe, economical, biocompatible, and biocompatible. Among the species employed in green synthesis include plants, bacteria, fungi, algae, and others. They eliminate the need for additional barriers and allow for the large-scale production of ZnO NPs (21). Biomimetic NPs have a higher catalytic activity and use fewer costly and hazardous ingredients. ZnO NPs have been made from plant parts such as leaves, stems, roots, fruits, and seeds because of the special phytochemicals they produce (22). Natural plant component extracts are an inexpensive, low-impact method that eliminates the need for any intermediary base groups. It generates a highly pure and quantity-enriched product free of impurities in a fraction of the time and without the need for costly equipment or precursors. Since they can produce stable NPs in a range of sizes and forms and can be produced on a big scale, plants are the most widely used source of NP synthesis. Metal ions or metal oxides are reduced to zero valence metal nanoparticles (NPs) using phytochemicals that are generated by the plant, including polysaccharides, polyphenolic compounds, vitamins, amino acids, alkaloids, and terpenoids (23).

Application in cosmetic and dermatology:

Rapid progress in this field during the past two years has increased the number of consumer goods based on nanotechnology that are accessible on the global market by 185%. More than 20 countries are currently producing and marketing over 600 different kinds of consumer goods based on nanotechnology, with cosmetics being the largest category. Sunscreen is among the most extensively used and well-liked consumer goods that use nanotechnology. Traditionally, traditional inorganic sunscreen particles such as zinc oxide (ZnO) and titanium dioxide (TiO2) tend to make skin appear white because of their larger size and propensity to scatter most visible light. UVA and UVB rays from the sun can damage skin cells through the action of free radicals. Zinc oxide nanoparticles (ZnO NPs) produced biologically have a special set of characteristics that set them apart from their counterparts that are produced conventionally. As a result, they are ideal for a wide range of cosmetic applications. In addition to highlighting the growing use of ZnO NPs in sunscreens, skincare products, and other cosmetic formulations, this section examines these unique characteristics.

Unique properties of biologically synthesized ZnO NPs:

ZnO NPs created via biological synthesis have distinct properties from those made by conventional chemical methods, including size, shape, and surface charge. These special qualities help to improve safety and efficacy, which are important Comparing biologically produced ZnO NPs to their chemically produced counterparts, the former frequently show lower and more consistent diameters (24). The overall effectiveness of cosmetic formulations is enhanced by this greater surface area, which makes it easier to interact with skin cells (25). ZnO NPs' stability and capacity to interact with other ingredients in cosmetic compositions are significantly influenced by their surface charge. Nanoparticles with specific surface charges can be produced using biological synthesis techniques, improving their compatibility with a variety of cosmetic components (26). Because they are more biocompatible, ZnO NPs produced biologically are less likely to cause negative skin reactions. One of the main reasons they are suitable for cosmetic applications is their improved biocompatibility, especially in products made for skin types that are sensitive or reactive (27).

Application in sunscreens and skincare products:

The unique features of biologically produced ZnO NPs have made them popular in sunscreens. A translucent and aesthetically pleasing appearance on the skin is made possible by the small particle size and enhanced dispersion qualities, which solve the long-standing problem of the white cast that conventional zinc oxide sunscreens cause (28). Furthermore, ZnO NPs are essential for creating effective sunscreens due to their intrinsic broad-spectrum UV protection properties. Biologically produced ZnO NPs are used in a variety of skincare products, such as lotions, creams, and anti-aging formulas, in addition to sunscreens. Their better skin penetration and active ingredient administration are facilitated by their improved size uniformity and biocompatibility (29). ZnO NPs are also useful additions to formulations aimed at skin health and renewal because of their antioxidant qualities (25).

Conclusion:

In conclusion, ZnO NPs are positioned as adaptable and effective ingredients in cosmetic compositions due to the special qualities bestowed by biological manufacturing techniques. A paradigm change in the cosmetics sector is represented by their use in sunscreens, skincare products, and other formulations, highlighting the critical role that biologically produced nanoparticles play in satisfying the changing needs of customers looking for safer and more efficient cosmetic solutions.

References

*Corresponding Author: **Idrees**

1. Findik FJPENS. Nanomaterials and their applications. 2021;9(3):62-75.
2. Joudeh N, Linke DJJoN. Nanoparticle classification, physicochemical properties, characterization, and applications: a comprehensive review for biologists. 2022;20(1):262.
3. Salvioni L, Morelli L, Ochoa E, Labra M, Fiandra L, Palugan L, et al. The emerging role of nanotechnology in skincare. 2021;293:102437.
4. Khan F, Shariq M, Asif M, Siddiqui MA, Malan P, Ahmad FJN. Green nanotechnology: plant-mediated nanoparticle synthesis and application. 2022;12(4):673.
5. Alqarni LS, Alghamdi MD, Alshahrani AA, Nassar AMJJoC. Green nanotechnology: Recent research on bioresource-based nanoparticle synthesis and applications. 2022;2022(1):4030999.
6. Dubey SK, Dey A, Singhvi G, Pandey MM, Singh V, Kesharwani PJC, et al. Emerging trends of nanotechnology in advanced cosmetics. 2022;214:112440.
7. Al Jabri H, Saleem MH, Rizwan M, Hussain I, Usman K, Alsafran MJL. Zinc oxide nanoparticles and their biosynthesis: overview. 2022;12(4):594.
8. Jiang Z, Liu B, Yu L, Tong Y, Yan M, Zhang R, et al. Research progresses in preparation methods and applications of zinc oxide nanoparticles. 2023;956:170316.
9. Khanna N, Tamrakar RK, Tiwari S, Upadhyay KJRiIC. ZnO metal oxide nanoparticle as biological tool. 2024;44(2):167-90.
10. Khanna N, Tamrakar RK, Tiwari S, Upadhyay K. ZnO metal oxide nanoparticle as biological tool. Reviews in Inorganic Chemistry. 2024;44(2):167-90.
11. Chanda S, Donga S, Pande JJZOP, Properties, Applications. Green synthesized zinc oxide nanoparticles: a review of antimicrobial, antioxidant, cytotoxic and photocatalytic properties. 2020:1-45.
12. Sricharussin W, Threepopnatkul P, Neamjan NJF, Polymers. Effect of various shapes of zinc oxide nanoparticles on cotton fabric for UV-blocking and anti-bacterial properties. 2011;12:1037-41.
13. Chanda S, Donga S, Pande J. Green synthesized zinc oxide nanoparticles: a review of antimicrobial, antioxidant, cytotoxic and photocatalytic properties. Zinc Oxide: Production, Properties and Applications. 2020:1-45.
14. Sharma S, Pande SS, Swaminathan PJRa. Top-down synthesis of zinc oxide based inks for inkjet printing. 2017;7(63):39411-9.
15. Betke A, Kickelbick GJI. Bottom-up, wet chemical technique for the continuous synthesis of inorganic nanoparticles. 2014;2(1):1-15.
16. Sharma S, Pande SS, Swaminathan P. Top-down synthesis of zinc oxide based inks for inkjet printing. RSC advances. 2017;7(63):39411-9.
17. Kołodziejczak-Radzimska A, Jesionowski TJM. Zinc oxide—from synthesis to application: a review. 2014;7(4):2833-81.
18. Mirzaei H, Darroudi MJCI. Zinc oxide nanoparticles: Biological synthesis and biomedical applications. 2017;43(1):907-14.
19. Abdelmigid HM, Hussien NA, Alyamani AA, Morsi MM, AlSufyani NM, Kadi HAJM. Green synthesis of zinc oxide nanoparticles using pomegranate fruit peel and solid coffee grounds vs. chemical method of synthesis, with their biocompatibility and antibacterial properties investigation. 2022;27(4):1236.
20. Alwan RM, Kadhim QA, Sahan KM, Ali RA, Mahdi RJ, Kassim NA, et al. Synthesis of zinc oxide nanoparticles via sol–gel route and their characterization. 2015;5(1):1-6.
21. Singh RP, Shukla VK, Yadav RS, Sharma PK, Singh PK, Pandey ACJAML. Biological approach of zinc oxide nanoparticles formation and its characterization. 2011;2(4):313-7.
22. Bandeira M, Giovanela M, Roesch-Ely M, Devine DM, da Silva Crespo JJSC, Pharmacy. Green synthesis of zinc oxide nanoparticles: A review of the synthesis methodology and mechanism of formation. 2020;15:100223.
23. Ishak NM, Kamarudin S, Timmiati SJMRE. Green synthesis of metal and metal oxide nanoparticles via plant extracts: an overview. 2019;6(11):112004.
24. Raszewska-Famielec M, Flieger JJIJoMS. Nanoparticles for topical application in the treatment of skin dysfunctions—an overview of dermo-cosmetic and dermatological products. 2022;23(24):15980.
25. Sajid M, Azam MSM, Ikhlaq WM, Ali S, Mateen A, Abbas H, et al. Nanomedicines Utilizing Trace Elements as Targeted Intervention to Revolutionize Diabetes Treatment.
26. Khabir Z, Holmes AM, Lai Y-J, Liang L, Deva A, Polikarpov MA, et al. Human epidermal zinc concentrations after topical application of ZnO nanoparticles in sunscreens. 2021;22(22):12372.
27. Niska K, Zielinska E, Radomski MW, Inkielewicz-Stepniak IJC-bi. Metal nanoparticles in dermatology and cosmetology: Interactions with human skin cells. 2018;295:38-51.
28. Subramaniam VD, Prasad SV, Banerjee A, Gopinath M, Murugesan R, Marotta F, et al. Health hazards of nanoparticles: understanding the toxicity mechanism of nanosized ZnO in cosmetic products. 2019;42(1):84-93.
29. Chauhan R, Kumar A, Tripathi R, Kumar A. Advancing of zinc oxide nanoparticles for cosmetic applications. Handbook of consumer Nanoproducts: Springer; 2022. p. 1-16.

*Corresponding Author: **Idrees**