International Standard Serial Number (ISSN): 2249-6807

International Journal of Institutional Pharmacy and Life Sciences 16(3): May-June 2026

INTERNATIONAL JOURNAL OF INSTITUTIONAL PHARMACY AND LIFE SCIENCES

Pharmaceutical Science

Research Article……!!!

Received: 22-02-2026; Revised: 27-04-2026; Accepted: 23-05-2026

GREEN SYNTHESIS OF ZINC OXIDE NANOPARTICLES USING ALOE VERA LEAF EXTRACT AND TO FORMULATE AND EVALUATE A SUNSCREEN CREAM

Rohini V. Patil, Samiksha D. Patil, Pranjal S. Gholap, Samiksha P. Warke

Shree. P.E.(Tatya) Patil Institute of Pharmacy, Jalgaon 425003, Maharashtra, India.

Keywords:

Green synthesis, creams, sunscreen, nanoparticles, spreadability, herbal formulation

For Correspondence:

Samiksha D. Patil

Shree P.E (Tatya) Patil Institute of Pharmacy, Jalgaon. 425003-Maharashtra.

E-mail:

samikshadevpatil@gmail.com

ABSTRACT

The project is based on the biological (green) synthesis of zinc oxide nanoparticle using plant extract from aloe vera. The phytochemicals present in aloevera such as flavonoids, phenolic compounds, polysaccharides, and proteins act as reducing and stabilizing agents. These compounds converted zinc ions (Zn^{+2}) from zinc salts into zinc oxide nanoparticles through a reduction reaction. An antimicrobial sunscreen is a topical pharmaceutical or cosmetic formulation designed to protect the skin from harmful ultraviolet (UV) radiation while simultaneously inhibiting the growth of microorganisms on the skin. The present study focuses on the green synthesis of zinc oxide nanoparticles using aloe vera leaf extract and their incorporation into a topical sunscreen cream formulation. The prepared formulation showed smooth texture, good consistency, and uniform appearance without any phase separation. The pH, viscosity, spredability of the creams were in the ranges of 6.7, 277.0 mPa's at 6 RPM, 5 cm/gm/sec respectively.

Introduction

The human skin may be rightly described as the natural 'perimeter fence' of the human body. It is situated between the internal protective, sensory and excretory functions.

Skin provides an immune barrier against microorganisms. The skin contains various bacterial species, however they rarely infect people. Bacterial skin infection can range from little to large and from begin to life-threatening. Skin damage makes wounds susceptible to bacterial infection, showing skin regeneration and healing. Skin infection caused by multidrug-resistant bacteria can kill people with significant burns and chronic illness like diabetes. Thus, a broad spectrum drug that kills bacteria without antibiotics is in high demand.

The project is based on the biological synthesis of zinc oxide nanoparticle using plant extract from aloevera. Zinc oxide nanoparticles (ZnONPs) are metal nanoparticles that have garnered significant interest due to thei distinctive shape and antimicrobial efficacy against both gram-positive and gram-negative bacteria. The antimicrobial efficacy of ZnONPs is associated with their interactions with cell membrane constituents, including bonding with amino acids, membrane depolarization and the stimulation of reactive oxygen species (ROS) formation. Moreover, nanofabrications has challenges related to aggregation, potential cytotoxicity, and high material costs.

During the synthesis process, the plant extract reduce zinc ions to form ZnO nanoparticles and also stabilizes them to prevent aggregation. This method is considered eco-friendly, cost-effective and non-toxic compared to conventional chemical synthesis methods.

The present study focuses on the green synthesis of zinc oxide nanoparticles using aloe vera leaf extract and their incorporation into a topical sunscreen cream formulation. The synthesized nanoparticles are characterized using various analytical techniques, and the formulated cream is evaluated for its physical properties, stability, sun protection factor, and antimicrobial activity. This approach aims to develop an effective, safe, and environmentally friendly sunscreen formulation suitable for pharmaceutical and cosmetic applications.

Aloe vera is a well-known medicinal plant widely used in traditional and modern medicine. It contains various bioactive compounds such as flavonoids, phenolics, vitamins, enzymes, and polysaccharides, which play a crucial role in the reduction and stabilization of metal ions during nanoparticles synthesis. The use of aloe vera extract in the green synthesis of ZnO nanoparticles not only enhances biocompatibility but also adds therapeutic properties like antioxidant, anti-inflammatory, and antimicrobial effects.

Conventional methods for the synthesis of nanoparticles, often involve toxic chemicals, high energy consumption, and environmental hazards. Therefore, there is an increasing demand for eco-friendly, cost-effective, and sustainable methods. Green synthesis of nanoparticles using plant extracts has emerged as a promising alternative, as it eliminates the use of hazardous substances and utilizes natural reducing and stabilizing agents present in plants.

In natural plants, aloe vera is a significant medicinal plant with antibacterial, anti-inflammatory, and antimicrobial properties, the gel of aloe vera leaf is a source of different organic acids, enzymes, .phenolic compounds, vitamins and minerals. Herein, aloe vera is widely used in the food, pharmaceutical and cosmetic industries, in the preparation of metal oxide and metal nanoparticles, the free carboxylic and amino groups derived from aloe vera extract act as both bio-reducing and capping agents, while glucomannan and acemannan extracted from aloe vera are considered as the natural active antimicrobial agents.

Materials and Methodology

(A) Green synthesis of ZnO nanoparticles using aloe vera –

1. Wash fresh leaves thoroughly with distilled water.
2. Remove outer green peel and collect the inner gel.
3. Weight 25g og gel.
4. Add to 100ml distilled water.
5. Heat at 60-70^{0}C for 20 minutes.
6. Cool and filter using muslin cloth or whatman filter paper.
7. Store extract at 4^{o}C for further use.

(B) Synthesis of zinc oxide nanoparticles

Step 1 - Preparation of zinc solution

a. Dissolve 2.2g zinc acetate dihydrate in 100ml distilled water
b. Stir using magnetic stirrer until completely dissolved

Step 2 – Addition aloe extract.

a. Add 20ml aloe vera extract slowly to zinc solution.
b. Stir continuously at 60^{o}C for 30 minutes.

Step 3 – Precipitation.

a. Prepare 0.5M NaOH solution separately.
b. Add NaOH dropwise into reaction mixture.
c. Maintain pH around 10-12.
d. White precipitation will form – indicates ZnO formation.

Step 4 – Aging

a. Continue stirring for 1hr at 60-70^{o}C.

Step 5 - Washing

a. Centrifuge at 5000 rpm for 10 minutes.
b. Wash precipitate with distilled water.
c. Wash again with ethanol.

Step 6 – Drying

a. Dry at 100^{o}C for 4-5 hour in hot air oven.

Step 7 - Calcination

a. Heat dried powder at 400^{o}C for 2 hour in muffle furnace.
b. Obtain fine white ZnO nanoparticle powder.

(C) **Formulation of antimicrobial sunscreen cream**.

Step 1- Oil phase

a. Take stearic acid, cetyl alcohol, and liquid paraffin.
b. Heat at 70-75^{o}C until melted.

Step 2 – Aqueous phase

a. Take distilled water.
b. Add glycerin.
c. Dissolved triethanolamine.
d. Heat at 70^{o}C.

Step 3 – Emulsification

a. Slowly add aq. Phase to oil phase with continuous stirring.
b. Stir until smooth emulsion forms.

Step 4 -Incorporation of ZnO nanoparticles

a. Disperse ZnO nanoparticles in small amount of glycerin.
b. Add slowly into cream base.
c. Stir continuously for uniform distribution.

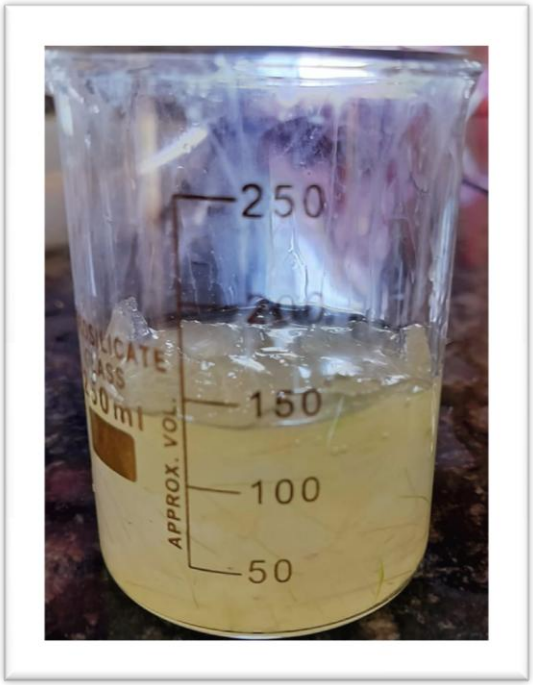
Step 5 - Cooling.

a. Add preservative below 40^{o}C
b. Stir until cool.
c. Transfer into clean container.

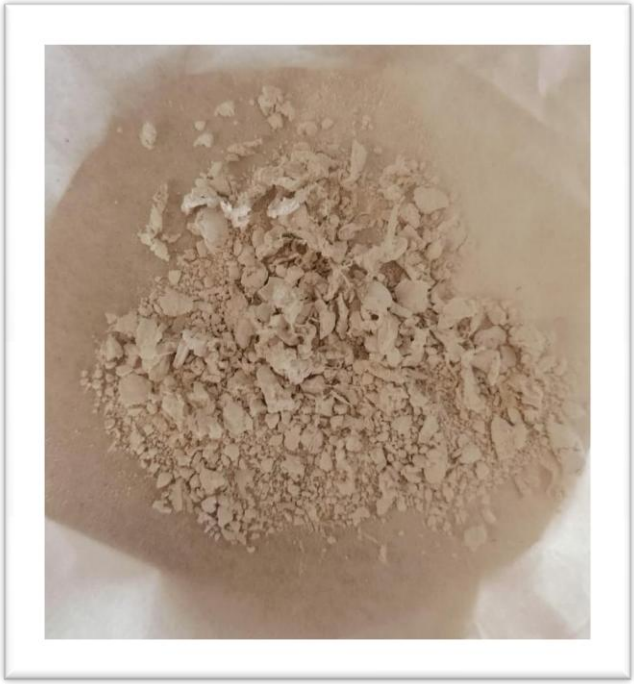
Result and Discussion

Synthesis of zinc oxide nanoparticles

Fig 01 is the green extract obtained from fresh aloe vera leaves. Upon addition of 60ml aloe vera extract to 300ml of the zinc acetate dihydrate solution. Under continuous stirring at 60^{o}C. Then, for the precipitation 20ml sodium hydroxide solution of 0.5M was used to added dropwise to adjust pH around 10-12. The mixture was stirred continuously for 1 hour at 60-70^{o}C. After centrifugation, washing & drying (24hours) formation of white precipitate indicated ZnO nanoparticles.



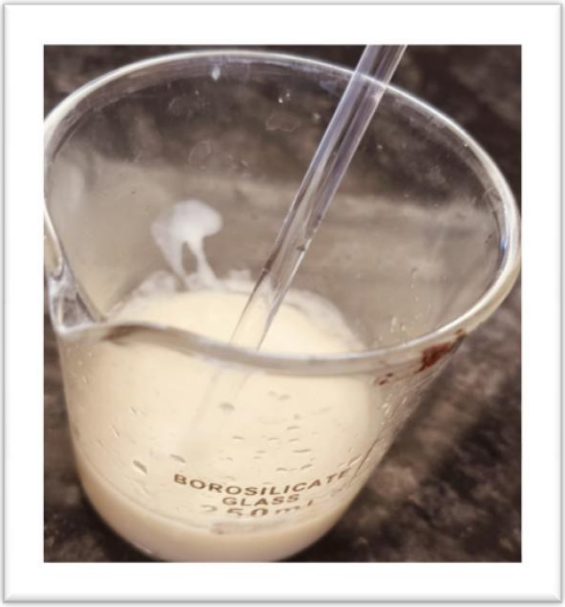
(fig.01)



(fig.02)

Formulation of Sunscreen Cream

Stearic acid, Cetyl alcohol, Liquid paraffin was taken to make oil phase. Whereas, Distilled water, Glycerin &Triethanolamine was taken to make aqueous phase. Both phases was heated to 70-75^{o}C until melted. Then, aqueous phase was slowly added to oil phase with continuous stirring. Fig, 03 shows that the ZnO nanoparticles were disperse into small amount of glycerin & slowly added into cream base.



(fig.03)

The sunscreen cream containing green synthesized ZnO nanoparticles using aloe vera leaf extract was successfully formulated and evaluated, the prepared formulation showed smooth texture, good consistency, and uniform appearance without any phase separation.

The cream was pale green in color with characteristics odor and showed good homogeneity. The formulation spread easily skin surface, indicate good spreadability and patient acceptability. The cream was non-greasy in nature and easily washable with water.

No signs of irritation, redness, itching were observed during irritancy studies, indicating that the formulation was safe for skin application.

The pH of the formulation was found to be compatible with skin and suitable for topical application. pH = 6.7

The viscosity of the formulated sunscreen cream was evaluated using Brookfield viscometer. The formulation showed optimum viscosity, which indicates good consistency and ease of application on the skin.

The obtained viscosity value confirmed that the cream was neither too thick nor too thin and could be easily spread on the skin surface. Proper viscosity also helps in maintaining stability and uniform distribution of ZnO nanoparticles throughout the formulation.

The viscosity remained almost constant during the stability study, indicating good physical stability of the sunscreen cream.

The viscosity of the given sample was found to be 277.0mPa's at 6 RPM.

Conclusion

The present study successfully demonstrated the green synthesis of zinc oxide nanoparticles (ZnONPs) using aloe vera leaf extract as a natural reducing and stabilizing agent. The method used was simple, economical, eco-friendly, and avoided the use of harmful chemicals. The synthesized ZnO nanoparticles were effectively incorporated into a sunscreen cream formulation and evaluate for various physicochemical parameters.

The formulated sunscreen cream showed good appearance, homogeneity, spreadability, washability, pH, viscosity, and stability indicating that the formulation was suitable for topical application. The cream also exhibited satisfactory sun protection activity due to provided soothing, moisturizing, and antioxidant benefits to the skin.

From the evaluation studies, it was concluded that the prepared herbal sunscreen cream was stable, safe, and effective for skin application. Thus, green synthesized ZnO nanoparticles can be considered a promising and environmentally friendly ingredient for the development of herbal sunscreen formulation with enhanced cosmetic and protective properties.

References

1. Afaq, F., & Mukhtar, H. (2006). Effects of solar radiation on cutaneous detoxification pathways. Journal of Photochemistry and Photobiology B. Biology, 85(2), 1010-110.
2. Dhillon, G.S., Brar, S. K., Kaur, S., &Verma, M. (2012). Green approaches for nanoparticle biosynthesis by microorganisms. Critical Reviews in Biotechnology, 32(1), 49-73
3. Romanus C. Omesh, Ibeabuchi J. Ali, Cyril C. Adonu, Josephat I. Ogbonna, Lydia O. Ugorji, Chukwuemeka C. Mbah, Celestine O. Ugwu, Felix K, AsogwaAssumpta A. Omeh, Goodnews O. Ikeh, Audu M. Mommoh, Godswill C. Onunkwo, et al. Green synthesis of zinc oxide Nanoparticles Characterization and Use for Formulation of Sunscreen Topical Creams. 2025
4. Noor Ahmed Kshash, Ali S. Ahmed. Antibacterial and Cytotoxicity Effects of Aloe Vera Leaves Extract Gel and Zinc Oxide Nanoparticles (ZnO NPs) on Bacterial Skin Infections.2025
5. S. Sonia, H. Linda JeevaKumari, K. Ruckmani, M.Sivakumar et al. Antimicrobial and antioxidant potentials of biosynthesized

colloidal zinc oxide nanoparticles for a fortified cold cream formulation: A potent nanocosmeceutical application. 2017

6. Padallia, H., Moteriya, P., & Chanda, S. (2015). Green synthesis of silver nanoparticles from marigold flower and its synergistic antimicrobial potential. Arabian Journal of Chemistry, 8(5), 732-741
7. Singh, J., Dutta, T., Kim, K. H., Rawat, M., Samddar, P., & Kumar, P. (2018). Green synthesis of metals and their oxide nanoparticles: Applications for environmental remediation. Journal of Nnaobiotechnology, 16 (1), 84.
8. Nohynek., G. J. &Dufour, E. K. (2012). Nano-sized cosmetic formulations or solid nanoparticles in sunscreens: A risk to human health? Archives of Toxicology , 86(7), 1063-1075.
9. Smijis, T. G., & Pavel, S. (2011). Titanium dioxide and zinc oxide nanoparticles in sunscreens: Focus on their safety and effectiveness. Nanotechnology, Science and Applications, 4,95-112.
10. Surjushe, A., Vasani, R., &Saple, D. G. (2008). Aloe vera: A short review. Indian Journal of Dermatology, 53(4), 163-166.
11. Kumar, V., Yadav, S. K. (2009). Plant-mediated synthesis of silver and gold nanoparticles and their application. Journal of Chemical Technology and Biotechnology, 84(2), 151-157.
12. Sharma, V.K.,Yngard, R. A., & Lin, Y. (2009). Silver nanoparticles: Green synthesis and their antimicrobial activities. Advances in Colloid and Interface Science, 145(1-2), 83-96.
13. Kaur, P., Thakur, R., &Chaudhury, A. (2016). Biogenesis of zinc oxide nanoparticles using plant extracts and their applications. International Journal of Nanoscience, 15(02), 1650003.
14. Lachman L, Lieberman HA, Kanig JL. The Theory and Practice of Industrial Pharmacy. 3rd ed. Mumbai: Varghese Publishing House; 2009.
15. Aulton ME. Aulton's Pharmaceutics: The Design and Manufacture of Medicines. 5th ed. Elsevier; 2018.
16. Khandelwal KR. Practical Pharmacognosy: Techniques and Experiments. 23rd ed. NiraliPrakashan; 2015.
17. Barel AO, Paye M, Maibach HI. Handbook of Cosmetic Science and Technology. 4th ed. CRC Press;2014.
18. Sangeetha G, Rajeshwari S, Venckatesh R. Green synthesis of zinc oxide nanoparticles by Aloe vera leaf extract and their antimicrobial activity. Asian J Pharm Clin Res. 2011;4(4) 1-4.
19. Vijaykumar S, Vinoj G, Malaikozhundan B. Biosynthesis of ZnO nanoparticles using plant extracts and their antibacterial activity. Materials Science in Semiconductor Processing. 2015;39:1-7.
20. Ramesh M, Anbuvannan M, Viruthagiri G. Green synthesis of ZnO nanoparticles using plant extracts and their antibacterial activity. SpectrochimicaActa Part A. 2015;136:864-870.
21. Singh P, Kim YJ, Zhang D, Yang DC. Biological synthesis of nanoparticles from plants and microorganisms. Trends Biotechnol. 2016;34(7):588-599.
22. Surjushe A, Vasani R, Sapale DG. Aloe vera: A short review. Indian J Dermatol. 2008;53(4):163-166.
23. Hamman JH. Composition and applications of Aloe vera leaf gel. Molecules. 2008;13(8):1599-1616.
24. Mitchnick MA, Fairhurst D, Pinnell SR. Microfine zinc oxide (ZnO): A review of its use in sunscreens. J Am AcadDermatol. 1999;40(1):85-90.
25. Jones N, Ray B, Ranjit KT, Manna AC. Antibacterial activity of ZnO nanoparticles. FEMS Microbial Lett. 2008; 279(1):71-76.
26. Ijoma KI, Ajiwe VIE, Ndubuisi JO. Evidence – based preferential in vitro antisickling mechanism of three native Nigerin plants used in the management of sickle cell disease. Malays J BiochemMol Biol. 2022; 3. 9-17

27. Harbone JB. Phytochemical methods: A guide to modern techniques of plant analysis. (1sted.) London; Chapman and Hall: 1973. 109 p
28. Yang X., Trinh HM, Agrahari V, Sheng Y, Pal D ,Mitra AK. Nanoparticle-based topical ophthalmic gel formulation for sustained release of hydrocortisone butyrate. AAPS PharmSciTech. 2016.
29. Rowe RC, Sheskey PJ, Owen SC (eds) Handbook of Pharmaceutical Excipients. London: Pharmaceutical press; 2006.
30. Yu HK, Yee KT, Jaspreet SK, Hairui L, Ai-Ling P, Lifeng K. Handbook of cosmeceutical Excipients and their Safeties. Singapor; Woodhead Publishing Series in Biomedicine; 2014
31. Dutra EA, Daniella A. Goncalves C, Oliveira E. Rosa M, Rocha M, Santoro M. Determination of sun protection factor (SPF) of sunscreens by ultraviolet spectrophotometry.
32. Savita G, Anjali B, Drashti T, Pratik P, Mamta C, Sarita K, Niral M, Mohammad K, Mir WA, Virendra KY, Maha AA, Krishna KY. Recent trends in the synthesis, characterization and commercial applications of zinc oxide nanoparticles – a review. InorganicaChimicaActa. 2024.
33. Aljamali, N.M; AI-Zubaidy, Z.H.; Enad, A.H.; Bacterial infection and common bacterial diseases. A Review. Pharm. Nanotechnol. 3: 13-23, 2021.
34. Qiu, L.; Wang, C.; Lan, M.; Guo, Q .; Du, X.; Zhou, S.; Cui, P.; Hong, T.; Jiang, P.; Wang, J.; Xia, J.; " Antibacterial photodynamic gold nanoparticles for skin infection". ACS Applied Bio Materials. 4(4): 3124- 3132,2021.
35. Iosageanu, A.; Mihai, E.; Seciu- Grama, A.M.; Utoiu, E.; Gaspar- Pintiliescu, A.; Gatea, F.; Cimpean, A.; Craciunescu, O.; "In Vitro Wound- Healing Potential of Polysaccharide Extracts of Aloe vera Gel". Journal of Functional Biomaterials, 15(9): 266, 2024.
36. Arsene, M.M.; Viktorovna, P.I.; Sergei, G.V.; Hajjar, F.; Vyacheslavovna, Y.N.; Vladimirovna, Z.A.; Aleksandrovna, V.E.; Nikolayevich, S.A.; Sachivkina, N,; " Phytochemical analysis, antibacterial and antibiofilm activities of Aloe vera aqueous extract against selected resistant Gram-negative bacteria involved in urinary tract infections". Fermentation 8(11): 626,2022.
37. Kumar, R.; Umar, A.; Kumar, G.; Nalwa, H.S.; " Antimicrobial properties of ZnO nanomaterials: A review". Ceramics International 43(5): 3940-3961, 2017.
38. Esmaeili, Y.; Zamindar, N.; Paidari, S.; Ibrahim, S.A.; MohammadiNafchi, A.; " The synergistic effects of Aloe vera gel and modified atmosphere packaging on the quality of strawberry fruit". Journal of Food Processing and Preservation 45(12): e16003,2021
39. Abd EL-Tawab, A.; Abo EI-Roos, N.; EI-Gendy, A.A.M.E.; "Effects of Zinc Oxide Nanoparticles on Staphylococcus aures isolated from cows mastitic milk". Benha Veterinary Medical Journal 35(1): 30-41, 2018.
40. R. Sahana, S.C.G.K. Daniel, S.G. Sankar, G. Archunan, S.J. Vennison, M. Sivakumar, Green Chem. Lett. Rev. 7 (2014)64.
41. T.S. Kumar, D. Venkappayya, V.N.R.K. Reddy, R. Manavalan, Int J Pharm. Bio. Sci 4 (2013)889.
42. G. Baskar, J. Chandhuru, K.S. Fahad, A.S. Praveen, Asian J. Pharm. Technol. 3(2013) 142.
43. G.R. Navale, M. Thripuranthaka, S.S. Shinde, JSM Nanotechnol. Nanomed. 3 (2015) 1.

HOW TO CITE THIS ARTICLE

Rohini V. Patil, Samiksha D. Patil, Pranjal S. Gholap, Samiksha P. Warke: Green synthesis of zinc oxide nanoparticles using aloe vera leaf extract and to formulate and evaluate a sunscreen cream. International Journal of Institutional Pharmacy and Life Sciences, Vol 16[3] May-June 2026 : 07-12.