RESEARCH ARTICLE

Synthesis, Formulation and Evaluation of Zinc Oxide Nanoparticle of *Capparis zeylanica* L. Stem

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ABSTRACT

The current study's focus is on using *Capparis zeylanica* L. stem extract to produce nanosized zinc oxide (ZnO) biologically in a way that is economical, effective, and environmentally safe. The synthesized nanoparticles were characterized using several techniques such as UV-Vis spectroscopy, TEM, FTIR and UV-vis spectroscopy. UV-vis spectroscopy ranges 200 to 400 nm. Having particle size 248 nm having zeta potential -3.5 mV with different groups. The current work examined by formation of gel, which shows good spreadability.

Keywords: Nanoparticles, Zinc oxide, *Capparis zeylanica,* Particle size, Zeta potential.

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INTRODUCTION

Nanomaterials are considered one of the most efficient materials in modern materials science with greater uses in various fields, from advanced fabric composites and food processing to agricultural production and cutting-edge medical treatments. It involves the synthesis, characterization, and study of materials on the nanoscale. The shift toward green methods in nanoparticle production has minimized the dependency on traditional methods.

Zinc oxide nanoparticles (ZnO NP), for instance, can be synthesized through various chemical methods such as precipitation, vapor transfer, hydrothermal synthesis and the reaction of zinc with alcohol.[1]

The field of green nanotechnology, which is fast developing, tries to address the advancement of ecologically sustainable nanotechnology applications. For millennia, studies on the use of plants have been drawn to the diversity of plants, particularly in traditional herbal plants. In recent decades, metal oxide nanoparticles have found widespread application in medicine. Because they can operate as a catalyst to assist in reducing or removing dangerous substances from the environment, metal-oxide nanoparticles have applications in the environment.[2]

Zinc oxide nanoparticles (ZnO NP) are used to remove harmful substances from various water resources and it is possible due to the lower particle size as well as higher surface area. ZnO also has diverse applications in the food, pharmaceutical and agriculture industries. These nanoparticles show promise as an alternative to pollution degradation in the environment. Additionally, ZnO nanoparticles have potential medical uses, including drug delivery, it also show antimicrobial, antifungal, anticancer and antioxidant properties, as well as roles in disease diagnosis.[3]

METHODOLOGY

Preparation of zinc oxide Nanoparticles

A 1 mM solution of zinc acetate was prepared by dissolving it in 50 mL of Milli-Q water and stirring for 1-hour. Then, 20 mL of NaOH solution was gradually added to the zinc acetate solution, followed by the addition of 25 mL of plant extract. After one hour of incubation, a color change in the reaction mixture was observed. The solution was then stirred for 3 hours, and the yellow color that appeared confirmed the formation of ZnO nanoparticles (ZnO NP). The precipitate was separated by centrifugation at 8000 rpm for 15 minutes at 60°C, and the resulting pellet was dried in a hot air oven at 80°C for 2 hours. The dried ZnO NP were stored in airtight bottles for future research.[4] The schematic presentation is outlined in Figure 1.

Evaluation of Nanoparticles

An analytical equipment called a UV-vis spectrophotometer (Jasco-V-730) A spectrometer. Some of the samples are considered for UV-vis examination and absorbance was taken at 200 to 400 nm.[5] The zeta potential (ZP) is a useful and easily

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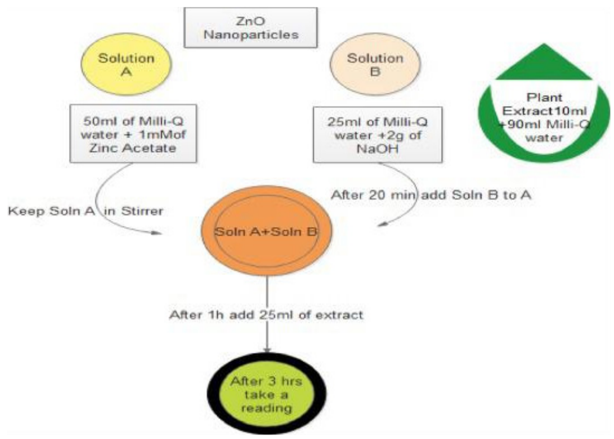

Figure 1: Schematic presentation of ZnO nanoparticles synthesis

measured indicator of colloidal dispersions' stability. The ZP indicates the level of electrostatic repulsion between similarly charged particles in a dispersion. A high ZP enhances the stability of small molecules and particles, helping to prevent their agglomeration in the solution or dispersion.

When the zeta potential is low, significant repulsion may be insufficient, causing the dispersion to destabilize and flocculate.[6] According to Horiba Scientific, all nano pharmaceutical formulations need to take particle size and distribution into account. The process of characterizing materials as organic, polymeric, or occasionally inorganic is known as infrared spectroscopy analysis, or FTIR spectroscopy (JASCO FTIR-410). The analysis uses infrared light to scan materials and assess their chemical properties. TEM, on the other hand, utilizes transmitted electrons to generate an image. As the electron beam passes through the specimen, its interaction with the sample produces an image, which is then magnified and projected onto a fluorescent screen, photographic film, or a detector such as a scintillator connected to a charge-coupled device, among other imaging tools.

Development of Topical Nano Gel

The nanosized topical gel formulation was made using a cold mechanical technique. Hydroxypropyl methylcellulose (HPMC) and Carbopol-940 were the two polymers utilized. On the flat surface, 80 deionized water (80 mL), a total of 2 g of each polymer were evenly dispersed. For the polymers to fully absorb, the mixture was allowed overnight. ZnO NP was added in an amount of 16 mg/mL. After adding two grams of glycerol to the nanogels, 100 mL of deionized water was added.[7,8]

Evaluation of Nano Formulation[9-12]

Visual inspection was done for physical characteristics such color, smell, and straightness. An eye examination was used to verify the formulation's hue. A cutaneous application was used to verify the consistency of the formulation.

Gel pH

The pH of various gel formulations was measured using a digital pH meter. After dissolving one gram of gel in 100 mL of distilled water, the solution was left to stand for two hours.

Homogeneity

The homogeneity of every newly developed gel formulation was determined physically after the gel got settled into containers. The presence and appearance of any aggregates were examined.

Spreadability

Spreadability is measured by the time, in seconds, it takes for two slides to separate from an emulsified gel when a specific pressure is applied between them. Better spreadability comes from a lesser gaping period between the two slides. The spreadability of the gel formulation was determined by measuring the diameter of 1 mg of gel placed between horizontal plates (20×20 cm²) after one minute, with a standard weight applied to the upper plate.

The following equation was used to determine the spreadability

$S = M.L/T$

Where,

M = Weight applied on slide

L = Glass slide length

T = Separation time of slides

RESULT AND DISCUSSION

Visual observation

After synthesis of the Zinc oxide nanoparticles (ZnO NP) color change was observed, indicating the formation of nanoparticles. The nanoparticles of *Capparis zeylanica* L. Stem extract were successful. The optical properties play an important role in the drug delivery system.

UV spectroscopy

The confirmation of ZnO NPs synthesis is also carried out by using the UV spectrophotometer technique. The oscillation of nanoparticle electrons takes place at a definite wavelength as a result. The peak was observed between 200 to 400 nm wavelength. The details of the calibration curve with concentration vs absorbance are presented in Table 1 and Figure 2.

Zeta potential

Determining the zeta potential and size of zinc oxide nanoparticles (ZnO NP) synthesized from *C. zeylanica* L. stem extract usually requires specialized techniques like DLS. The measured zeta potential was found to be -3.5 mV as shown in Figure 3.

Table 1: Calibration curve with concentración vs absorbance

Concentration (μg)	*Absorbance*
0.1	0.1988
0.2	0.3466
0.3	0.47738
0.4	0.6423
0.5	0.7974

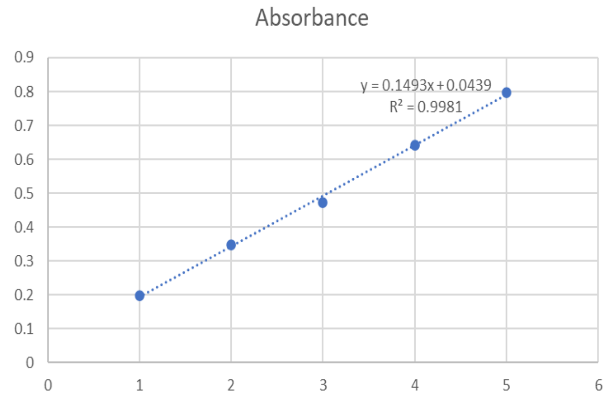

Figure 2: Calibration curve

Particle size determination

There exist two fundamental techniques for determining the particle size as well as distribution. First, the particles are examined and their diameters are measured directly. The link between particle behavior is utilized in the second way. The particle size distribution is presented in Figure 4.

FTIR

The molecules' substance-specific vibrations produce the unique signals detected by infrared spectroscopy. The zinc oxide nanoparticles (ZnO NP) synthesis functional group and its FTIR spectra showed a peak in the range of 1000 to 3500 cm^{-1} (Figure 5). The protein's amide-I stretch ranges from 1456.72C to 1456.72C, and the broad peak found at 3425.65 corresponds to OH stretching vibrations. Alkane and aldehyde (H-C=O) are indicated by the strong peaks found at 2923.54 and 2859.64. The presence of carbonyl, ester, and amine resp is indicated by the peaks at 1730.57, 1274.15, and 1125.67. The

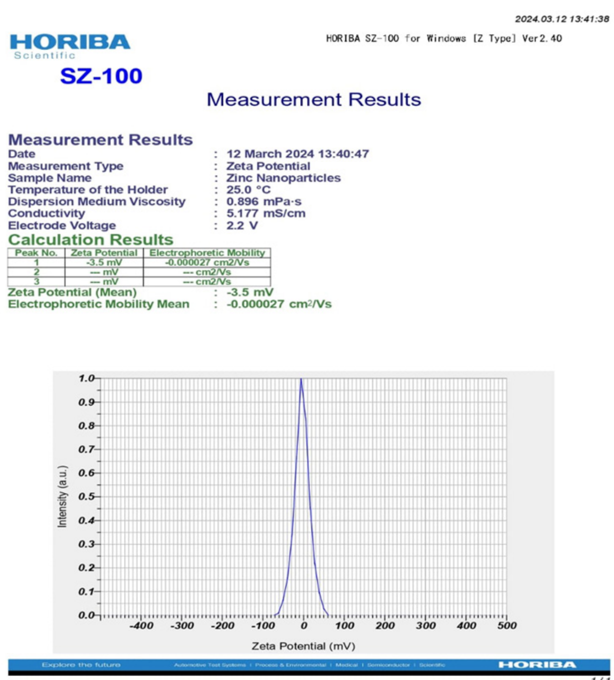

Figure 3: zeta potential of ZnO nanoparticles

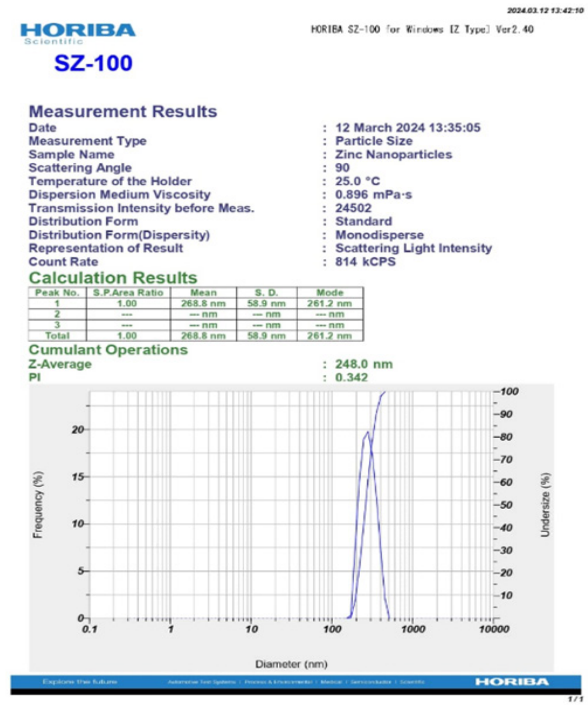

Figure 4: Particle size distribution of ZnO NP

aromatic compound 736.46 showed a straight chain stretch, while the weak peaks found at 1072.33 and 954.03 reflect alkenes.

Transmission electron microscopy (TEM)

The higher resolution and clarity in TEM is possible due to the short de Broglie wavelength than the regular light microscopy. This capability allows TEMs to visualize structures at the atomic level, which are thousands of times smaller than the smallest resolvable objects in light microscopy, thus providing highly detailed images. TEM is a crucial analytical method in the physical, chemical, and biological sciences. It is widely used in various fields, including pollution studies, nanotechnology, and semiconductors. TEM of ZnO nanoparticles is presented in Figure 6.

Evaluation of gel parameters

Various gel evaluation parameters are presented in Table 2.

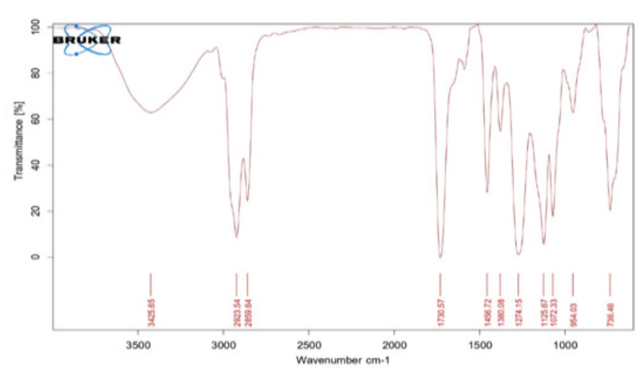

Figure 5: FTIR spectra of ZnO nanoparticles

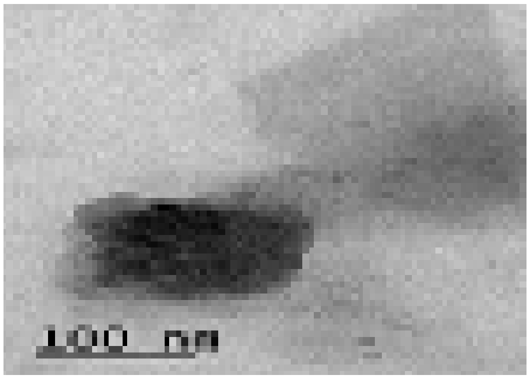

Figure 6: TEM of ZnO nanoparticles

Table 2: Gel evaluation parameters

Parameters	*Observatión*
Appearance	Green
Consistency	Good
Odor	Characteristic
Homogeneity	Good
Spreadability	Good

CONCLUSION

The method of green synthesis of nanoparticles is non-toxic and ecofriendly as it uses herbal extract. *C. zeylanica* L. Stem is used in this process owing to its many health benefits such as improving blood circulation, regulating the menstrual cycle, headaches, stomach pain, relief for liver problems, etc. Low particle size and high porosity contribute to their improved efficacy. UV absorption (UV-vis spectrophotometer). An intrinsic property of nanoparticles is characterized by their size determination, zeta potential, IR spectra (FTIR), and peak obtained between 200 to 400 nm. Clearly demonstrates the presence of ZnO NP in the reaction mixture. On further characterization size and zeta potential of synthesis nanoparticles were found to be 248.0 nm and -3.5 mV, respectively. From the obtained IR spectra, we can conclude the presence of OH stretching, phenol, C=O, ketone, alkanes, alkyl amine, etc. Using the prepared nanoparticle solution, the gel was formulated and evaluated and the spreadability of formulated gel was good by using the above formula. These findings not only support the traditional medicinal use of *C. zeylanica* L. stem but also highlight its potential for further investigation as a source of therapeutic agents.

REFERENCES

1. Kumar KK, Kiran V, Choudhary RK, Devhare LD, Gunjal SD. Design Development and Characterization of Nicardipine Solid Lipid Nano-Particulars. International Journal of Drug Delivery Technology. 2024;14(1):71-78. DOI: 10.25258/ijddt.14.1.12
2. Huang C, Peng L, Xu X, Lu Y, Wang X, Lan Z, et al. Preparation and characteristics of a thermosensitive in situ gel loaded with chitosan nanoparticles for optimal ocular delivery of chloramphenicol. Journal of Drug Delivery Science and Technology. 2023;89: 104962. DOI: https://doi.org/10.1016/j.jddst.2023.104962
3. Sheteiwy MS, Shaghaleh H, Hamoud YA, Holford P, Shao H, Qi W, Hashmi MZ, Wu T. Zinc oxide nanoparticles: potential effects on soil properties, crop production, food processing, and food quality. Environmental Science and Pollution Research. 2021 ;28(28):36942-36966.
4. Santhoshkumar J, Kumar SV, Rajeshkumar S. Synthesis of zinc oxide nanoparticles using plant leaf extract against urinary tract infection pathogen. Resource-Efficient Technologies. 2017 Dec 1;3(4):459-465. https://doi.org/10.1016/j.reffit.2017.05.001
5. Akash MS, Rehman K, Akash MS, Rehman K. Ultraviolet-visible (UV-VIS) spectroscopy. Essentials of pharmaceutical analysis. 2020:29-56.
6. Bhattacharjee S. DLS and zeta potential–what they are and what they are not? Journal of controlled release. 2016 Aug 10; 235:337-51. https://doi.org/10.1016/j.jconrel.2016.06.017
7. Rao KG, Ashok CH, Rao KV, Chakra CS, Rajendar V. Green synthesis of tio2 nanoparticles using hibiscus flower extract. In Proceedings of the International Conference on Emerging Technologies in Mechanical Sciences 2014 Dec 8 (pp. 79-82).
8. Bala N, Saha S, Chakraborty M, Maiti M, Das S, Basu R, Nandy P. Green synthesis of zinc oxide nanoparticles using Hibiscus subdariffa leaf extract: effect of temperature on synthesis, anti-bacterial activity and anti-diabetic activity. RSC Advances. 2015;5(7):4993-5003.
9. Nurman S, Yulia R, Irmayanti, Noor E, Candra Sunarti T. The optimization of gel preparations using the active compounds of arabica coffee ground nanoparticles. Scientia Pharmaceutica. 2019;87(4):32. https://doi.org/10.3390/scipharm87040032
10. Zulkurnain EI, Ramli S, Ali AA, James RJ, Kamarazaman IS, Halim H. The Phytochemical and Pharmacological Effects of Hibiscus rosa-sinensis: A Review. International Journal of Pharmaceutical Investigation. 2023;13(3):422-431 DOI:10.5530/ijpi.13.3.053
11. Gnana RPM, Devhare LD, Dharmamoorthy G, Khairnar MV, Prasidha R. Synthesis, Characterisation, Molecular Docking Studies and Biological Evaluation of Novel Benzothiazole Derivatives as EGFR Inhibitors for Anti-breast Cancer Agents. International Journal of Pharmaceutical Quality Assurance. 2023;14(3):475-480. DOI: 10.25258/ijpqa.14.3.03
12. Priya MGR, Prasanth LML, Devhare LD, Yazdan SK, Gunjal S. Synthesis, DNA Binding, Molecular Docking and Anticancer Studies of Copper (II), Nickel (II), and Zinc (II) Complexes of Primaquine-based Ligand. International Journal of Pharmaceutical Quality Assurance. 2024;15(1):69-75. DOI: 10.25258/ijpqa.15.1.10