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Thin Film Biosynthesis of Zinc Oxide Nanoparticles Using Thymus Serpyllum Plant Extract

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Abstract: Thin films of zinc oxide nanoparticles were made in this work with a Thymus serpyllum plant ex-tract. After the plant was gathered and thoroughly cleaned, a set of procedures was followed to make the plant extract. Next, one of the zinc compounds and the plant extract were used in a pro-cess that was shown to produce zinc oxide nanoparticles. Using infrared radiation, scanning elec-tron microscopy, and X-ray diffraction, the resultant nanocomposite was discovered and de-scribed. The findings demonstrated that the nanoparticles were layered and ranged in size from 20.29 to 65.30 nm.

Keywords: Silver Nanoparticles, Thymus Serpyllum Plant, Biosynthesis, Green chemistry.

الاصطناع الحيوي للأغشية الرقيقة لجسيمات أوكسيد الزنك النانوية باستخدام مستخلص نبات الزعتر البري

الدكتورة / رشا حسام صالح
كلية العلوم | جامعة تشرين | سوريا

المستخلص: هدفت الدراسة إلى تصنيع جسيمات أوكسيد الزنك النانوية باستخدام مستخلص نبات الزعتر البري. تم جمع النبات وتنظيفه بشكل جيد، ثم اتباع مجموعة من العمليات والإجراءات المحددة لتحضير المستخلص النباتي. بعد ذلك، تم إجراء تفاعل بين أحد مركبات الزنك والمستخلص النباتي الذي تم الحصول عليه لإنتاج جسيمات أوكسيد الزنك النانوية. تم توصيف المركب النانوي الناتج باستخدام مطيافية الأشعة تحت الحمراء، والمجهر الالكتروني الماسح وحيود الأشعة السينية. أظهرت النتائج أن الجسيمات النانوية الناتجة كانت عبارة عن طبقات، وتراوح حجمها بين 20.29، و65.30 نانومتر.

الكلمات المفتاحية: جسيمات الفضة النانوية، نبات الزعتر البري، الاصطناع الحيوي، الكيمياء الخضراء.

Introduction:

Since the special qualities that can be produced by shrinking the size to the nanoscale range, nanomaterials and composites have a wide range of applications [1]. Thin films, nanoparticles, and quantum dots are examples of nanotechnology, which has the potential to significantly advance fields as diverse as solar energy and medical diagnostics [2].

High-quality optical semiconductor materials, such as thin films made from nano-zinc oxide, are utilized in optical devices like photoelectric cells and light-emitting diodes [3]. Zinc oxide nanoparticles are currently regarded as significant substances because of their critical features resulting from their nanoscale size, particularly in scientific and technological applications. ZnO nanoparticles have a variety of characteristics, including as thermal stability, optical qualities, electrical conductivity, and the capacity to participate in a wide range of chemical reactions [4].

Because of its unique optical properties, nanoscale ZnO is utilized in the manufacturing of a wide range of optical devices, including light-emitting diodes (LEDs), solar cells, and screens. This makes nanomaterials technology incredibly significant [5]. Its electrical conductivity makes it useful in electronic applications including transformers, batteries, and capacitors. Its sensitivity to gases and humidity makes it useful in sensors as well as applications such as electrochemical water breakdown and sustainable energy production. Nano-ZnO's antibacterial and antimicrobial qualities play a significant impact [6].

Thymus serpyllum, also known as the wild thyme plant, is a kind of perennial herb that is a member of the Lamiaceae family. Its tiny leaves, powerful scent, and stunning violet blossoms set it apart. This plant has spread and is now utilized in many nations worldwide [7].

Thymus serpyllum's abundance of essential oils and bioactive substances contributes to its various health and therapeutic benefits. Because of its potent ability to fight against a variety of bacteria, including drug-resistant types like Staphylococcus aureus, it is known for being antibacterial. Because it contains ingredients like carvacrol and thymol, which can help with coughing, laryngitis, colds, and inflammation, it also aids in the treatment of upper respiratory infections. sinuses in the paranasm. Furthermore, this plant is notable for its antioxidant chemical content, which includes rosmarinic acid and may aid in bodily defense [8].

When compared to conventional approaches, the green way of creating chemical nanocomposites is becoming more and more popular because it uses less harmful processes and has a less environmental impact. This method's importance is increased by the fact that it is less expensive to produce, lowers energy consumption, and is environmentally benign because it requires lower temperatures or pressure [9].

Importance of Study:

Research on the thin-film biogenesis of ZnO nanoparticles utilizing extract from the wild thyme plant is highly significant for various reasons. Because wild thyme is a natural resource with minimal environmental impact, using natural ingredients in the production of ZnO nanoparticles helps achieve environmental sustainability goals. in contrast to conventional chemical techniques. When biosynthesized, zinc oxide nanoparticles can also be used to further advance innovation in a variety of technical applications, including solar cells, by increasing their efficiency and performance.

Researching how nanomembranes affect the antibacterial qualities of nanozinc oxide—which is employed in biological applications—is also crucial.

Study Structure:

This study was divided into three sections, the first section deals with the theoretical framework of the study and previous studies, while the second section deals with laboratory work, and the third section deals with the results and discussion.

The first section: The theoretical framework and previous studies:

First: The theoretical framework:

A complete grasp of ZnO nanotechnology and thin films, as well as their applications in fields including solar cell optimization, detector applications, and medicine, was the main focus of the literature survey conducted for this study. Apart from examining the significance of biosynthesis of nanomaterials, particular attention should be paid to the use of plant resources as they offer secure, economical, and eco-friendly methods for the synthesis of nanoparticles.

However, this study gave data on the efficiency of utilizing wild thyme in the biosynthesis process and was based on evidence that a variety of plant materials can be employed in the creation of nanoparticles.

Second: Previous studies:

1- Using the Thymbra Spicata L plant, researchers studied the green production, characterisation, and bioactivity of ZnO NPs and shown their efficacy against the fungus Bacillus subtilis ATCC 6633, Escherichia coli ATCC 25952, Pseudomonas aeruginosa ATCC 27853, and Candida albicans ATTC 90028, in that order [10].

2- Examination of the Properties of Thymus serpyllum L Extract Free and Added to Silica and Titania Nanoparticle Mesopores Showed Antimicrobial Potential for Thymus Serpyllum L Extracts [11].

3- investigation of the antibacterial action, production, and characterisation of iron nanoparticles produced by Thymus vulgaris L. FeNPs shown strong antifungal efficacy against Aspergillus flavus, Candida albicans, and C. parapsilosis [12].

4- Research on the environmentally friendly production of zinc oxide nanoparticles using leaf extract from Vernonia cinerea and their assessment as nanonutrients for tomato seedling growth and development [13].

5- An overview of the environmentally friendly production of zinc oxide nanoparticles from plant extracts and their potential uses in medicine. The study's findings supported the use of zinc oxide nanoparticles (ZnO NPs) in agriculture for the synthesis of fumigants, insecticides, and fertilizers by highlighting their unique properties. Botanically produced ZnO NPs have shown great promise in the medical and pharmaceutical industries for the synthesis of antiseptic, antifungal, anticancer, antioxidant, anti-inflammatory, and antidiabetic medicines [14].

6- investigation into the creation of trimeric zinc oxide nanoparticles produced from plant proteins that have built-in antibacterial and neurotoxic capabilities. N-ZnO Ps was investigated for its antibacterial efficacy against bacteria, including Klebsiella pneumoniae (K. pneumonia) and Escherichia coli (E. coli). N-ZnO Ps showed possible cytotoxicity on the human brain glioblastoma cell line LN-18, while they were harmless to HMC-3 human brain microglia. According to these findings, N-ZnOPs may prove to be effective antibacterial and anticancer treatments in the fight against glioblastoma [15].

The second topic - the practical section:

Firstly- Preparation of Extract of Thymus Serpyllum:

The Thymus serpyllum plant sample was collected from the highlands of the Syrian coast, then washed well with double-distilled water to get rid of any impurities that might be present, then dried well, and then ground using an electric grinder to obtain a fine powder for the extraction process.

An amount of 5g of plant powder was weighed, placed in a glass beaker, 500 ml of double-distilled water was added to it, and placed on an electric heater at a temperature of 60o degrees, with continuous stirring using magnetic stirring for 45 minutes, and a green solution was obtained, Lightly Yellowish color.

The resulting extract was cooled to room temperature, and then the filtration process was performed using filter papers and then a centrifuge at a speed of 1200 r/min. The resulting extract was stored in a glass beaker, with an aluminum foil cover placed on the nozzle of the preservation beaker to prevent any external contamination. Store it at 0°C for later use.

Secondly- Synthesis Zinc Oxide Nanoparticles (ZnO-NPs):

1 gr of zinc nitrate was weighed, added to 100 ml of double-distilled water, and placed on an electric heater at 60°C for 45 minutes, with continuous stirring using a magnetic stirrer to obtain a homogeneous solution.

After that, 10 ml of plant extract was added to the zinc nitrate solution, gradually with continuous stirring for an hour.

Then drops of sodium hydroxide at a concentration of 1 M were gradually added, and then the temperature was raised to 80 °C for half an hour.

Then, the resulting solution was slowly poured onto glass slides to prepare the thin film, and then placed in a desiccator at 60 °C.

The prepared silver nanoparticles were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), and fourier-transform infrared (FT-IR).

The third section - discussion of the results:

Firstly- X-Ray Diffraction Analysis

The results of XRD examination of the prepared ZnO nanostructured films showed that they were polycrystalline with a hexagonal system. The peaks of the spectrum of the resulting compound were compared with the reference spectra, and the locations of the resulting peaks were matched and the diffraction values were indexed at the locations (31.42°, 34.23° and 63.15°).

The growth of the crystals was in the crystallographic directions (100), (101), and (002), and the dominant direction among them was (002), as it is the peak with the highest intensity in the spectrum (Fig.1).

Wild thymus serpyllum plant extract contains polyphenolic compounds such as thymol and carvacrol, which act as natural restorative agents. These compounds convert zinc ions into nanoparticles through redox reactions [16].

The X-ray diffraction pattern showed the presence of distinct crystalline peaks, which confirms the crystallinity and direction of the hexagonal crystallization process of the zinc oxide nanoparticles.

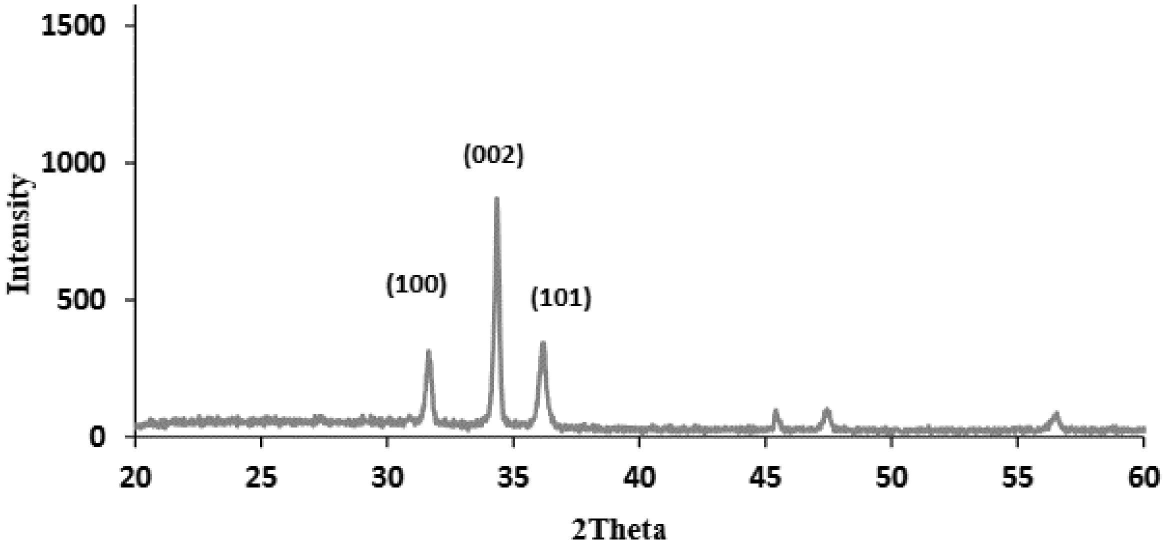

Fig (1): XRD of thin film of Zinc Oxide nanoparticles

Secondly- Scanning Election Microscope (SEM):

Using a scanning electron microscope SEM, the surface morphology of the resultant zinc oxide nanocomposite was examined. This revealed the hexagonal crystalline system, which takes the shape of layers on which the zinc oxide nanoparticles are situated. The resultant zinc oxide nanoparticle sizes varied between (20.29-65.30) nm, as demonstrated in (Fig. 2), according to the SEM image, which was caused by the plant extract's return.

Scanning electron microscope (SEM) images showed a uniform distribution of zinc oxide nanoparticles of specific size and shape, indicating precise control of the preparation process. In addition, the results showed the effect of the concentration of the plant extract on the size oxide and shape of the nanoparticles, which led to the formation of smaller, more uniform and closer-sized particles, indicating an increase in the interaction between the extract and zinc ions.

Some previous studies have shown the use of other plant extracts to prepare zinc oxide nanoparticles, such as bay leaf extract, however, the use of wild thyme extract resulted in smaller particle sizes and uniform distribution [17].

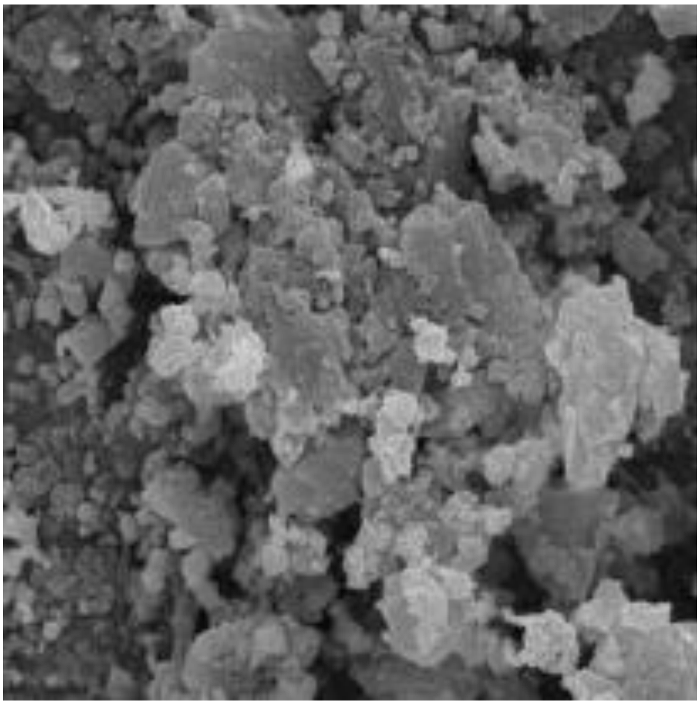

Fig (2): SEM of Zinc Oxide nanoparticles

Third- Fourier-Transform Infrared (FT-IR):

Plant extracts typically contain phenol, alcohol, amine, carboxylic acid, alkaloids, and terpenoids, which are responsible for the stabilization and recovery process of nanoparticles. Secondary re-ceptors are the primary factors in the creation of nanoparticles.

Infrared spectroscopy identified the presence of specific chemical functional groups on the surface of the zinc nanomembranes, and revealed the presence of chemical bonds between the wild thymus serpyllum extract and the zinc particles, which explained why the films were stable.

The prepared ZnO-NPs' FT-IR spectra revealed the presence of numerous distinct absorption bands, including 1200, 1450, 1600, 2800, 2900, and 3400. These bands are associated with the functional groups amine (NH_2), hydroxyl (OH), and carboxylate (COOH), which are involved in the stabilization and recovery processes.

The presence of the zinc oxide compound is shown by the values of the absorption bands in the 400–600 cm^{-1} range. This suggests that the resultant compounds are present between the layers of the manufactured zinc oxide nanoparticles.

The results indicate the formation of compounds between zinc ions and the plant extract. These compounds act as stabilizing agents and prevent agglomeration of nanoparticles, resulting in uniform distribution. Also, the interaction of compounds presents in the plant extract, such as thymol, with the surface of nanomembranes through various chemical bonds, such as hydroxyl-zinc bonds or others, leads to a change in the surface properties and thus provides new functions.

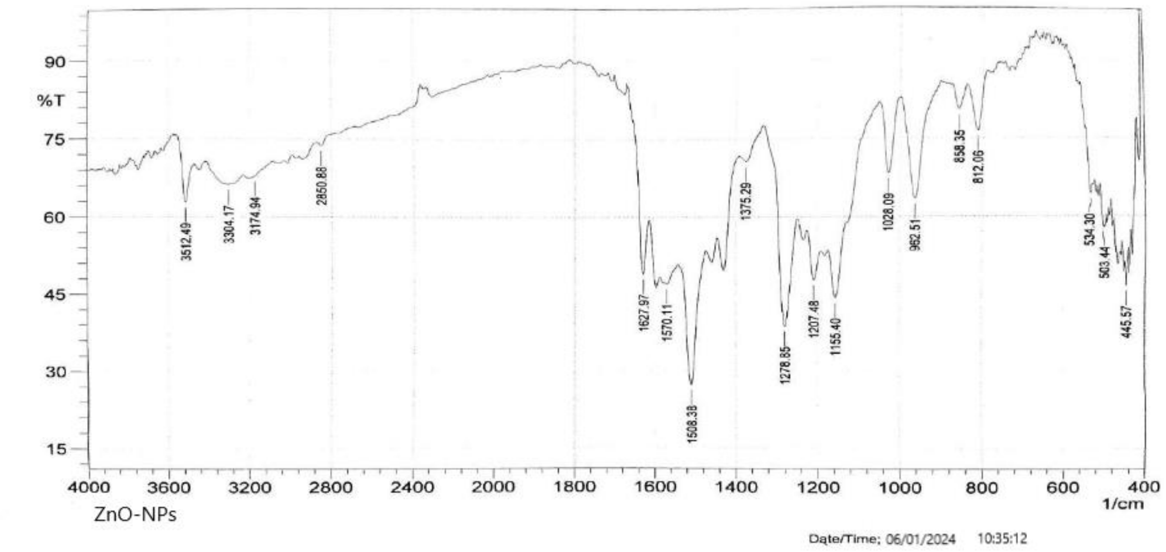

Fig (3): FT-IR of Zinc Oxide nanoparticles

Recommendations:

Based on the results reached, the study recommends the following:

In addition to evaluating the effectiveness of the formed nanoparticles in solar applications - taking into account the huge potential of nano-zinc oxide in improving solar cells, it is recommended to test the resulting nanoparticles on bacteria and fungi to determine their areas of application and effectiveness.

List of references:

[1]. Omanović-Mikličanin, E., Badnjević, A., Kazlagić, A., & Hajlovac, M. (2020). Nanocompo-sites: A brief review. Health and Technology, 10(1), 51-59.

[2]. Zakaria, M. A., Menazea, A. A., Mostafa, A. M., & Al-Ashkar, E. A. (2020). Ultra-thin silver nanoparticles film prepared via pulsed laser deposition: synthesis, characterization, and its catalytic activity on reduction of 4-nitrophenol. Surfaces and Interfaces, 19, 100438.

[3]. Mousa, M. A., & Khairy, M. (2020). Synthesis of nano-zinc oxide with different morpholo-gies and its application on fabrics for UV protection and microbe-resistant defense clothing. Textile Research Journal, 90(21-22), 2492-2503.

[4]. Pino, P., Bosco, F., Mollea, C., & Onida, B. (2023). Antimicrobial nano-zinc oxide biocom-posites for wound healing applications: a review. Pharmaceutics, 15(3), 970.

[5]. Aremu, O. H., Akintayo, C. O., Naidoo, E. B., Nelana, S. M., & Ayanda, O. S. (2021). Syn-thesis and applications of nano-sized zinc oxide in wastewater treatment: a review. Interna-tional Journal of Environmental Science and Technology, 1-20.

[6]. Khaleel, R. S., Hashim, M., & Majeed, S. G. (2022). Synthesis of ZnO thin film by chemical spray pyrolysis using its nano powder. Kuwait Journal of Science, 49(1).

[7]. Shahar, B., Indira, A., Santosh, O., Dolma, N., & Chongtham, N. (2023). Nutritional compo-sition, antioxidant activity and characterization of bioactive compounds from Thymus serpyl-lum L.: An underexploited wild aromatic plant. Measurement: Food, 10, 100092.

[8]. Kulbat-Warycha, K., Nawrocka, J., Kozłowska, L., & Żyżelewicz, D. (2024). Effect of Light Conditions, Trichoderma Fungi and Food Polymers on Growth and Profile of Biologically Active Compounds in Thymus vulgaris and Thymus serpyllum. International Journal of Molecular Sci-ences, 25(9), 4846.

[9]. Aldeen, T. S., Mohamed, H. E. A., & Maaza, M. (2022). ZnO nanoparticles prepared via a green synthesis approach: Physical properties, photocatalytic and antibacterial activity. Jour-nal of Physics and Chemistry of Solids, 160, 110313.

[10]. Gur, T., Meydan, I., Seckin, H., Bekmezci, M., & Sen, F. (2022). Green synthesis, characterization and bioactivity of biogenic zinc oxide nanoparticles. Environmental Research, 204, 111897.

[11]. Brezoiu, A. M., Prundeanu, M., Berger, D., Deaconu, M., Matei, C., Oprea, O., ... & Danciu, C. (2020). Properties of salvia officinalis L. and thymus serpyllum L. extracts free and embedded into mesopores of silica and titania nanomaterials. Nanomaterials, 10(5), 820.

[12]. Yehia, R. S., & Ali, A. M. (2020). Biosynthesis and characterization of iron nanoparticles produced by Thymus vulgaris L. and their antimicrobial activity. Acta Botanica Croatica, 79(2), 114-120.

[13]. Azim, Z., Singh, N. B., Khare, S., Singh, A., Amist, N., & Yadav, R. K. (2022). Green synthesis of zinc oxide nanoparticles using Vernonia cinerea leaf extract and evaluation as nano-nutrient on the growth and development of tomato seedling. Plant Nano Biology, 2, 100011.

[14]. Akintelu, S. A., & Folorunso, A. S. (2020). A review on green synthesis of zinc oxide nanoparticles using plant extracts and its biomedical applications. BioNanoScience, 10(4), 848-863.

[15]. Hou, T., Sankar Sana, S., Li, H., Wang, X., Wang, Q., Boya, V. K. N., ... & Mamidi, N. (2022). Development of plant protein derived tri angular shaped nano zinc oxide particles with inherent antibacterial and neurotoxicity properties. Pharmaceutics, 14(10), 2155.

[16]. Mokhtari, R., Kazemi Fard, M., Rezaei, M., Moftakharzadeh, S. A., & Mohseni, A. (2023). Antioxidant, antimicrobial activities, and characterization of phenolic compounds of thyme (thymus vulgaris l.), sage (salvia officinalis l.), and thyme–sage mixture extracts. Journal of Food Quality, 2023(1), 2602454.

[17]. Dalmaz, A., Kasımfırtına, E., & Sivrikaya Özak, S. (2024). Green synthesis of ZnO nanoparticles using Laurus nobilis L. extract and investigation of corrosion inhibition properties of DES-based nanofluids. Journal of the Iranian Chemical Society, 21(4), 1101-1112.