doi.org/10.52866/esj.2025.01.25.17

Preparation of Nano Zinc Oxide and Studying the Antibacterial activity on some bacteria groups

Hiba Jumaa Jaafer
basicsci4@uodiyala.edu.iq
Department of Science/College of Basic Education/University of Diyala , Baquba, Diyala Governorate, Iraq

Abstract :

In this study zinc oxide nanoparticles prepared by sol-gel method by using Zinc nitrate and urea . ZnO powder tested by x-ray diffraction (XRD) and the crystallite size determined by the Debye-Scherer equation was 38.69 nm . The field emission scanning electron microscopy (FE-SEM) For (ZnO)nanoparticles, showed that the particles is spherical form and agglomerations of some nanoparticles with an average nanosize of (56.422 nm). The antibacterial activity was conducted using nano-zinc oxide against two types of positive bacterial isolates, represented by (Staphylococcus aureus) and (Staphylococcus epidermidis isolates) and negative ones, represented by (Escherichia coli) and (Klebsiella pneumonia isolates).

Keywords: FE-SEM images, nanoparticles, Sol-Gel, zinc oxide .

تحضير أوكسيد الزنك النانوي ودراسة الفعالية البايلوجية على بعض المجاميع البكتيرية

هبة جمعة جعفر
قسم العلوم / كلية التربية الاساسية / جامعة ديالى

مستخلص:

تم في هذه الدراسة تحضير جزيئات أكسيد الزنك النانوية بطريقة السول جل باستخدام نترات الزنك واليوريا. تم اختبار المسحوق بواسطة حيود الأشعة السينية (وكان الحجم البلوري المحدد بواسطة معادلة ديباي شرر 38.69 نانومتر. أظهر الفحص بالمجهري الإلكتروني الماسح للجسيمات النانوية (ZnO) أن الجسيمات كروية الشكل وعبارة عن تجمعات لبعض الجسيمات النانوية بمتوسط حجم نانوي (56.422 نانومتر). تم اختبار الفعالية المضادة للبكتيريا باستخدام أكسيد الزنك النانوي ضد نوعين من العزلات البكتيرية الموجبة ممثلة بـ (Staphylococcus aureus) و (Staphylococcus epidermidis) والسلبية ممثلة بـ (Escherichia coli) و (Klebsiella pneumonia).

Introduction

Metal oxide nanoparticles are an important raw material with a wide range of uses in optical, mechanical, and electrical devices, gas sensors, catalysts, sunscreens, and cosmetics (1). 2. To prepare the nanoparticles, further chemical and physical techniques were applied. Yet, there are a lot of approaches that have drawbacks, such as the use of hazardous chemicals, toxic solvents, excessive energy consumption, etc., so it is essential to develop environmentally acceptable techniques for the synthesis of metallic nanoparticles. To increase the biological applications of materials, it is critical to develop environmentally friendly synthesis procedures. Currently, a wide range of green nanoparticles have been created using different techniques, exhibiting well-defined chemical composition, size, and morphology. Their potential uses have been investigated in numerous cutting-edge technological domains. (2) The procedure is more beneficial than other risky methods because of the regenerative properties of the plant extracts, the ecologically friendly aqueous medium, and the moderate reaction conditions. The energy efficiency, cheap cost, and benign nature of a variety of plant extracts and chemicals have drawn attention recently in the process of creating metallic nanoparticles (3)

ZnO nanoparticles, or zinc oxide Zinc oxide (ZnO) is one of the significant metal oxide nanoparticles that is currently receiving attention from scientists. Zinc oxide nanoparticles (ZnO.NPs) possess a distinct range of properties, including photochemical capabilities, fungicidal, antibacterial, and UV 3 filtering. These attributes render ZnO.NPs a versatile agent with increased potential for wastewater remediation (4). While there are numerous ways to make ZnO.NPs, such as chemical precipitation, solvothermal, hydrothermal, microwave, sonication, etc. This biosynthesis category's crucial component is the green production of ZnO.NPs using materials derived from plants. The process mainly entails extracts from various plant sections being used to produce the NPs, either with or without the use of coprecipitation agents and temperature. The many enzymes and phytochemicals in the extract primarily aid in the reduction/oxidation of the precursor to ZnO NPs, despite the fact that the process chemistry of the NPs preparation is excessively complicated (5). These plant-derived extracts contain a wide range of metabolites that are strong in antioxidants and quickly convert the precursor molecule to zinc ions and then ZnO.NPs.

Material and Method

The (Sol-gel) method is used to prepare nano zinc oxide. It involves dissolving 35 g of zinc nitrate in 35 ml of distilled water, adding 10 g of urea, and continuously mixing the mixture with a magnetic stirrer to obtain the final solution. The mixture is then filtered through filter paper to remove impurities. Zinc oxide gel is produced by heating the solution for three hours at 100 C. The gel is then dried for one hour at 250 C in an oven to produce the material. To verify the final material and its nano size, we evaluated it using FTIR, FESEM, and X-ray diffraction.

Antibacterial activity study

n this study, a clinical isolation of some patients from Baquba Teaching Hospital using the Vitek system was used. The bacteria (S. aureus (S. epidermidis)) were grown on blood agar medium, and E. coli (K. pneumonia) was grown on MacConkey medium.

A solution was prepared at concentrations (100, 50, and 25 mg/mL) by dissolving a weight of the prepared substance in ethanol, and the mixture was placed in a water bath operated with ultrasound waves.

Dissolve (38g) of Muller Hinton agar medium (with distilled water at a temperature of 121°C and under 15 lb pressure for 15 minutes. After dissolving the medium, a certain amount of it is poured into a petri dish. Always work next to a Bunsen lamp to obtain a sterile medium, and then leave it. Let it cool and freeze, then store it in the refrigerator, after which the tablet is sterilized through a lube.

Result and discussion

XRD analysis The crystal structure and phase identification of the zinc oxide nanoparticles are identified from the X-ray diffraction pattern with JCPDS card No. 01-079-0208 . The XRD spectra of the synthesized ZnO-NPs is show in Figure(1) Braggs diffraction peaks for ZnO-NPs is observed at 31.6_o, 34.3_o, 36.1_o, 47.3_o, 56.3, 62.6, 66.03, 67.6, 68.7, 72.3 and 76.5 in 100,002,101, 102, 110, 103, 200, 112, 201, 004 and 202 respectively, the average crystallite size calculated by using Scherer-equations.

$D = 0.94\lambda / \beta \cos \Theta$

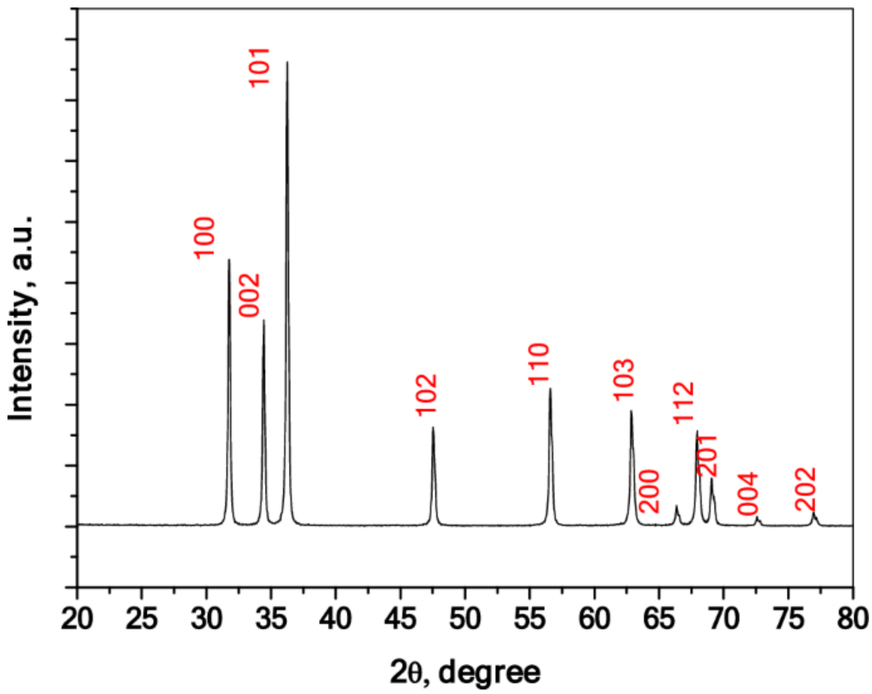
Where, D is represent size of particles(nm),

λ Is the wave length of the XRD (Cu $K\alpha = 1.54056\ _oA$),

β is the full width of the XRD peak at half height,

(Θ) is the Bragg-angle.

The absence of impurities was revealed by the X-ray diffraction pattern, which demonstrated that pure had been successfully synthesized.



Figure(1) XRD pattern of ZnO

(FE-SEM) images were taken of the surface of the prepared zinc oxide nanoparticles (ZnO) in Figures (2) . The first represents the shape of the nanostructure with magnification power (2000 kx)

We notice in Figure (2) the shape of zinc oxide nanoparticles prepared with sol-gel method, as the nanostructure has a rhombic shape with an irregular distribution. It is also possible to notice the appearance of agglomerations of some nanoparticles with an average nanosize of (56.422 nm) [6].

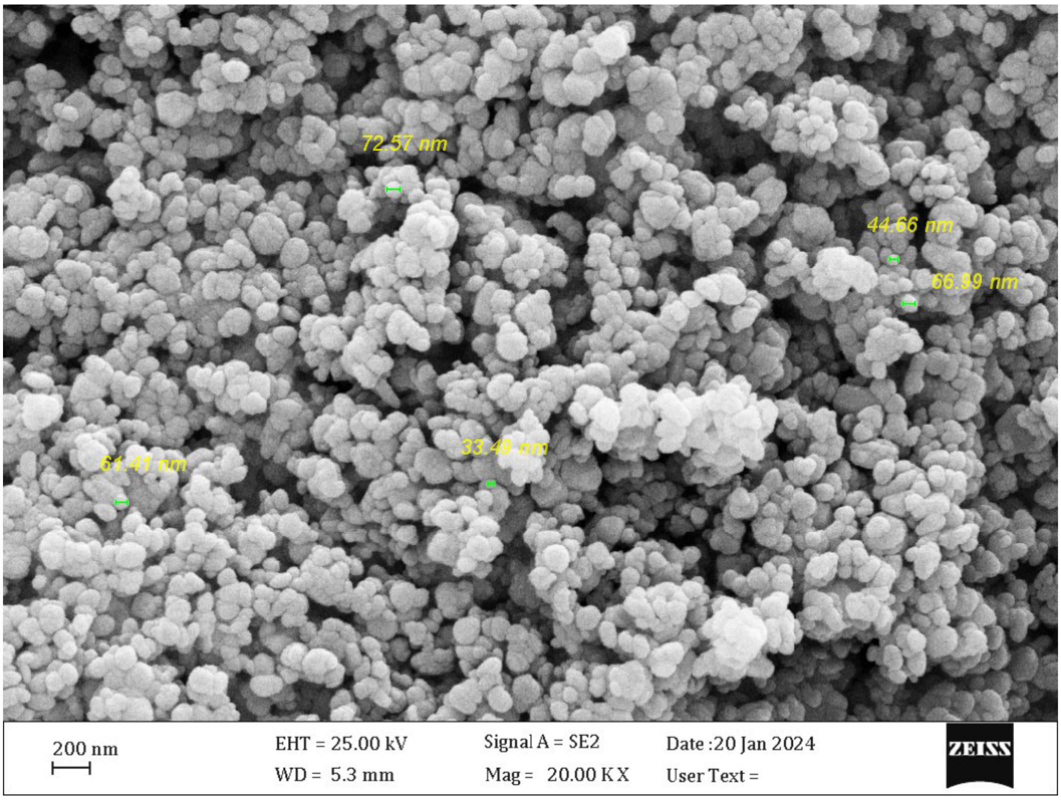


Figure (2): FE-SEM image of ZnO

Energy dispersive X-ray diffraction spectroscopy analysis shows the components and purity of nano-zinc oxide. We notice from Figure (3) that the elements composing the surface of nano-zinc oxide are (82.1% Cu =), and its high peak appeared at (0.8 kev) and (1 kev) and (6.1% O=) with an intermediate peak that appeared between (0.4 kev) and (0.6 kev), which constitutes the structural structure of nano-zinc oxide. Also, the presence of carbon is due to the use of filter papers during the preparation process As for the rest of the elements, chlorine, iron, and chromium, they result from contamination of laboratory tools and the fact that the material is impure. [7]

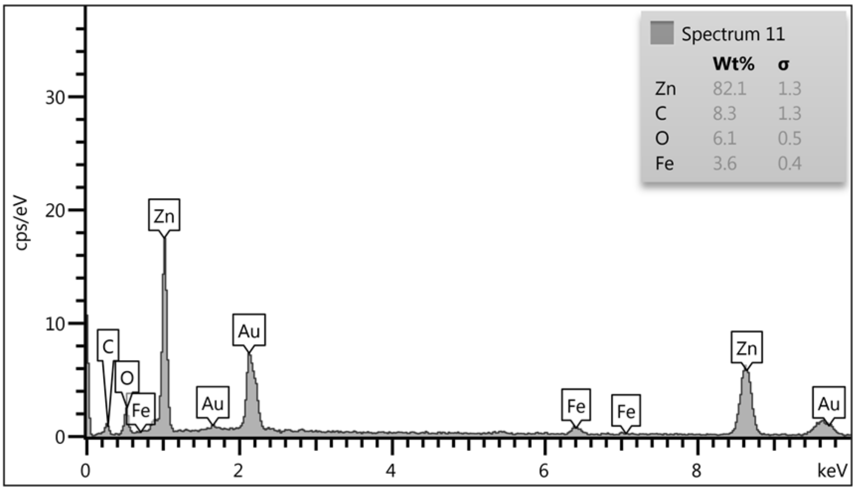


Figure (3): shows an energy dispersive X-ray spectroscopy image of the surface of prepared zinc oxide nanoparticles (ZnO).

The spectrum of ZnO-NPs powder were recorded, as shown in the Figure shows various bending and stretching band viz,3309,cm^{-1} , the broad band at (3309)cm^{-1} was related to the presence of O-H group. The band at (544)cm-1 is related to Zn-O bond, thus confirming the presence of Zn-O [8].

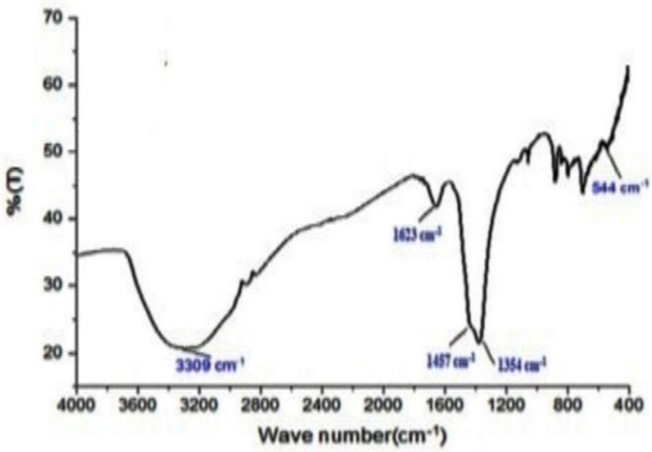


Figure (4): FTIR spectra of ZnO

The biological activity of prepared zinc oxide nanoparticles

The antibacterial activity was conducted using nano-zinc oxide against two types of positive bacterial isolates, represented by (Staphylococcus aureus) and (Staphylococcus epidermidis isolates) and negative ones, represented by (Escherichia coli) and (Klebsiella pneumonia isolates), as shown in Table (2) and with three Different concentrations are (25 mg/mL), (50 mg/mL) and (100 mg/mL), Note that these isolates were chosen because of their importance in the medical field, as they cause many diseases and have a high ability to resist chemotherapeutic agents and antibiotics. [9]

Table (2): shows the biological effectiveness of the prepared nano-zinc oxide.

S. aureus				*S. epidermidis*		
Con.	100	50	25	100	50	25
D	14 mm	13 mm	13 mm	12 mm	12 mm	11 mm
E. coli				*K. pneumonia*		
Con.	100	50	25	100	50	25
D	11 mm	10 mm	0 mm	11 mm	0 mm	0 mm

The table 2 shows that the highest inhibitory capacity of zinc oxide nanoparticles at concentrations of 100 mg/ml against S.aureus bacteria was 14nm.

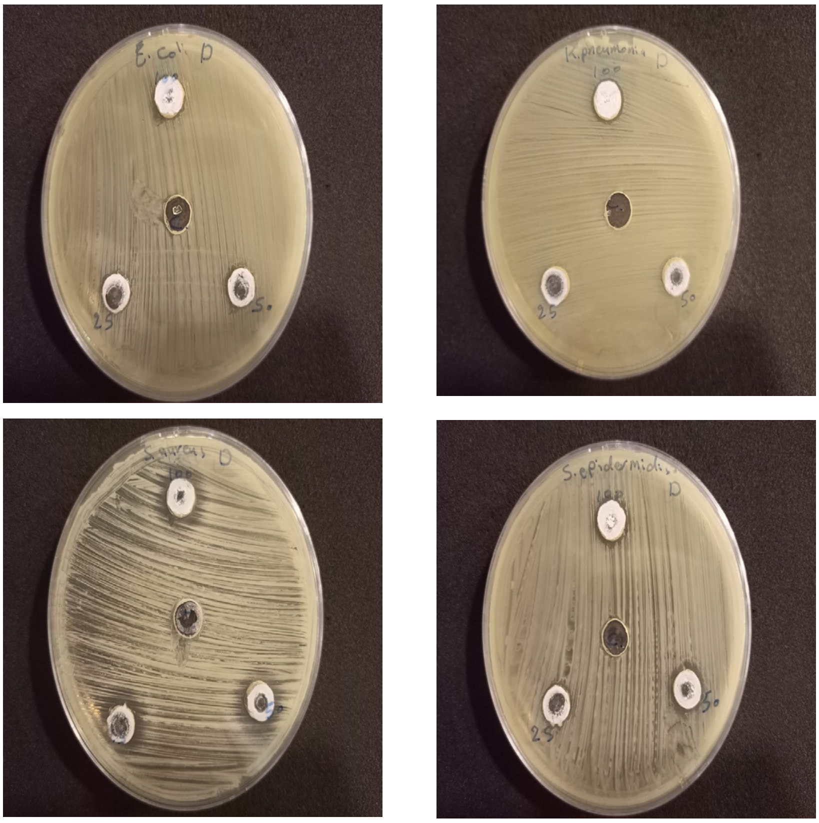


Figure (5): shows the result of cultivating bacterial species in dishes

Conclusion

1. The use Sol-gel method in preparing nano-zinc oxide was successful, effective, and a very simple method.

2. The prepared zinc oxide nanoparticles were characterized by X-ray diffraction, scanning electron microscope, and energy dispersive X-ray diffraction spectroscopy.

3- Zinc oxide Nano particle is good anti-bacterial against 4 types of bacteria .

References

[1] Zhao, X., Lv, L., Pan, B., Zhang, W., Zhang, S., and Zhang, Q. (2011). Polymer-supported nanocomposites for environmental application: a review. Chemical Engineering Journal, 170 (2), 381-394. 20

[2] Geraldes, A.N., Alves, A., Leal, J., Estrada-Villegas, G.M., Lincopan, N., Katti, K.V., and Lugao, A.B. (2016). Green nanotechnology from plant extracts: synthesis and characterization of gold nanoparticles. Advances in Nanoparticles, 5, 176-185.

[3] Nath, D., and Banerjee, P. (2013). Green nanotechnology–a new hope for medical biology. Environmental Toxicology and Pharmacology, 36 (3), 997-1014.

[4] Li, Z., Sun, Y., Xing, J., Xing, Y., & Meng, A. (2018). One step synthesis of Co/Cr-codoped ZnO nanoparticle with superb adsorption properties for various anionic organic pollutants and its regeneration. Journal of hazardous materials, 352, 204-214.

[5] Rambabu, K., Bharath, G., Banat, F., & Show, P. L. (2021). Green synthesis of zinc oxide nanoparticles using Phoenix dactylifera waste as bioreductant for effective dye degradation and antibacterial performance in wastewater treatment. Journal of hazardous materials, 402, 123560.

[6] Radhakrishnan, A. A., & Beena, B. B. (2014). Structural and optical absorption analysis of CuO nanoparticles. *Indian J. Adv. Chem. Sci*, *2*(2), 158-161.

[7] Sharmila, G., Pradeep, R. S., Sandiya, K., Santhiya, S., Muthukumaran, C., Jeyanthi, J., ... & Thirumarimurugan, M. (2018). Biogenic synthesis of CuO nanoparticles using Bauhinia tomentosa leaves

extract: Characterization and its antibacterial application. *Journal of Molecular Structure*, *1165*, 288-292.

[8] Das,G.,et al., Investigation of anti-oxidant, antibacterial, antidiabetic, and cytotoxicity potential of silver nanoparticles synthesized using the outer peel extract of Ananas comosus (L.).PloS one, 2019.14(8):p. e0220950

[9] K.M.M. Abou El-Nour, A. Eftaiha, A. Al-Warthan, R.A.A. Ammar, Synthesis and applications of silver nanoparticles, Arab. J. Chem. 3 (2010) 135e140,