Biophysical Characterization of Thin Films of Zinc Oxide Prepared by Sol-Gel

Abothur Almohana[1*], Radea Hateem Jawad[2]

Abstract

In this research, ZnO nano-powder was used, and the work was in two biological and physical parts. Where the work of the first part was to examine the effect of ZnO powder on *Staphylococcus aureus*, and the result of inhibition was 100%. As for the second part, the preparation of a thin film by the Sol-Gel method, where thin films were deposited on glass, the structural properties and topography of the surface were studied. The prevailing trend (101). Also, the results of the atomic force microscopy (AFM) tests showed that the resulting granular size of the prepared and annealed films with a temperature (400 ° C) was less than 100 nm, wherein an anti-bacterial nanoscale S. aureus was made.

Key Words: Zinc Oxide, Thin Films, Biological Sensors.

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Introduction

Previous years have shown that biomedical engineering and nanotechnology are the most advanced scientific disciplines. Nanotechnology and biomedicine allow us to increasingly receive new composites that are beginning to play an important role in medicine. Nanotechnology is a rapidly developing field that makes it possible to obtain and test materials that have at least one dimension less than 100 nanometers and thanks to this science, we can create new products that are better and have improved chemical, physical and biological properties [1]. Although many studies have been conducted. On the biological activity of ZnO, however, most of it related to the antimicrobial effect of ZnO with large particle size. Several antimicrobial chemicals have been banned worldwide due to their carcinogenic effect and environmental toxicity.

Now there is an urgent need to develop such antimicrobial materials that would be beneficial to health and the environment [2]. Zinc oxide is a non-toxic and abundant material, and therefore it is abundant in nature, relatively inexpensive, and has a relatively wide energy gap ((3.37v), which made it have many applications in several fields, including physical, medical, and others [3].

Where zinc oxide can be prepared in the form of a thin film, where the deposition of thin films is always on its ground and it is made of glass, silicon, aluminum or quartz and others, depending on the nature of the study [4]. Therefore, this fact must be taken into account during the preparation of the membrane, which is that the nature of the substrate has a great impact on the structural properties of the thin films deposited on it [5].

Corresponding author: Abothur Almohana
Address: [1*]Jaber Ibn Hayyan Medical University, College of Medicine, Iraq; [2]Babil Education Directorate, Babylon, Iraq.
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One of the important factors to know the compositional properties that depend on X-ray diffraction (XRD) is the calculation of the distance between the crystalline levels (dhkl), which is calculated using Bragg's Law and according to the following relationship [6].

$$n\lambda = 2d\sin\theta \quad (1)$$

θ_B =Bragg's angle
dhkl the distance between the crystalline levels
λ The incident x-ray wavelength
m is an integer representing the order of reflection
G.s grain size can be calculated from the following Debye-Scherrer equation [7]

$$G.s = \frac{k\lambda}{\beta.cos\theta} \quad (2)$$

The width of the curve (in radian) at (FWHM) (Full Width at Half Maximum).
: Bracke's angle (degrees).
k: Scherer's constant.

Materials and Methods

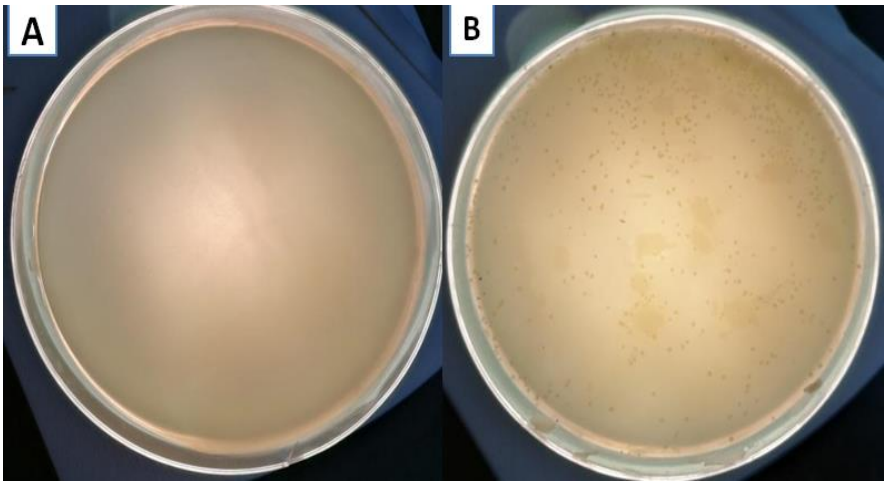
The work on ZnO nanoparticles was in two parts: the biological part used ZnOnano powder with a granular size of 30-50 nm, where it was thermally treated at a temperature of C 400. Mixing 0.5 g of ZnO nanoparticles with 10 ml of distilled water using magnetic stirrer. Then 1 ml was taken from it and added to 20 ml from the agar medium at a temperature of 80 C, then poured into plates, left 45 min, then the S. Arae bacteria were planted, and it was also planted in a control medium plate. Prepared medium of Muller Hinton agar by dissolving 3.8 grams of the medium. In 95 ml of distilled water, the autoclave was sterilized at 121 C for 15 minutes and left to cool at 45 C. 5 ml of ZnOnano solution added to it. Mix the medium well and pour into Petri dishes (20 ml per dish) and leave to be soy. The plates were inoculated with S. aureus bacteria equal to McFarland tube No. 0.5 by diffusion method and incubated for 24 hours at 37 C. The absence of growth was a positive result. As for the second physical part, the thin films were prepared by the Sol-Gel method in combination with the spin coating method on a glass floor. It is known that the impurities have a significant impact on the accuracy of the resulting measurements.

1. It should be washed with running water and one of the cleaning powders, to get rid of stains or remnants of materials or dust attached to them.
2. Put it under running water for a period of (15) minutes to ensure that the cleaning powder comes off.
3. It is submerged in the distillation water to be washed automatically by an Ultrasonic device for a period of (15 minutes).
4. The pure ethanol alcohol is immersed in the basin to be washed automatically using the same previous device for the same period.
5. Then it is dried by using a special cloth and placed with a special container for the bases.

Whereas, this method is characterized by its ease and availability of tools. Where the solution is prepared using (0.5 g) of zinc oxide with 30 ml of ethanol mixed with 6 ml of acetic acid after it was left for 20 hours, drops of the mixture were placed on the glass floor and due to the acceleration of the central gravity in the spread of the material and its coating on All of the substrate and thus leaving it from it causes a thin layer of material to form on the substrate. The thickness of the film and its properties depend on the nature of the material solution, viscosity, drying rate, and other parameters such as rotation speed. Where the rotation rate was (3000 rpm) and the sample was heated at 100°C for a period of (3s) for the purpose of drying, and after the completion of the membranes preparation and drying, they were annealed at 400 °C for an hour.

Results and Discussion

The work of the first part was biological, as no bacterial growth was shown, meaning inhibition was 100%, as in figure (1A), while the growth of the control plate appeared normal growth as in figure (B1) and through the process of merging in the work between biology and physics an anti-bacteria nano-film was found for S. arae, as in the biological part, the results showed that ZnO powder is an inhibitor of S. arae and it is non-toxic (source). The physical part, making a thin film of ZnO, using the X-ray technique to study the crystal structure of the material powder (ZnO), and through it, the purity of the powder was confirmed by comparing the diffraction pattern with the material card JcpdsZnO (numbered 96-901-1663). It was distinguished by the emergence of a number of peaks, including (100) (101) (002) (110).



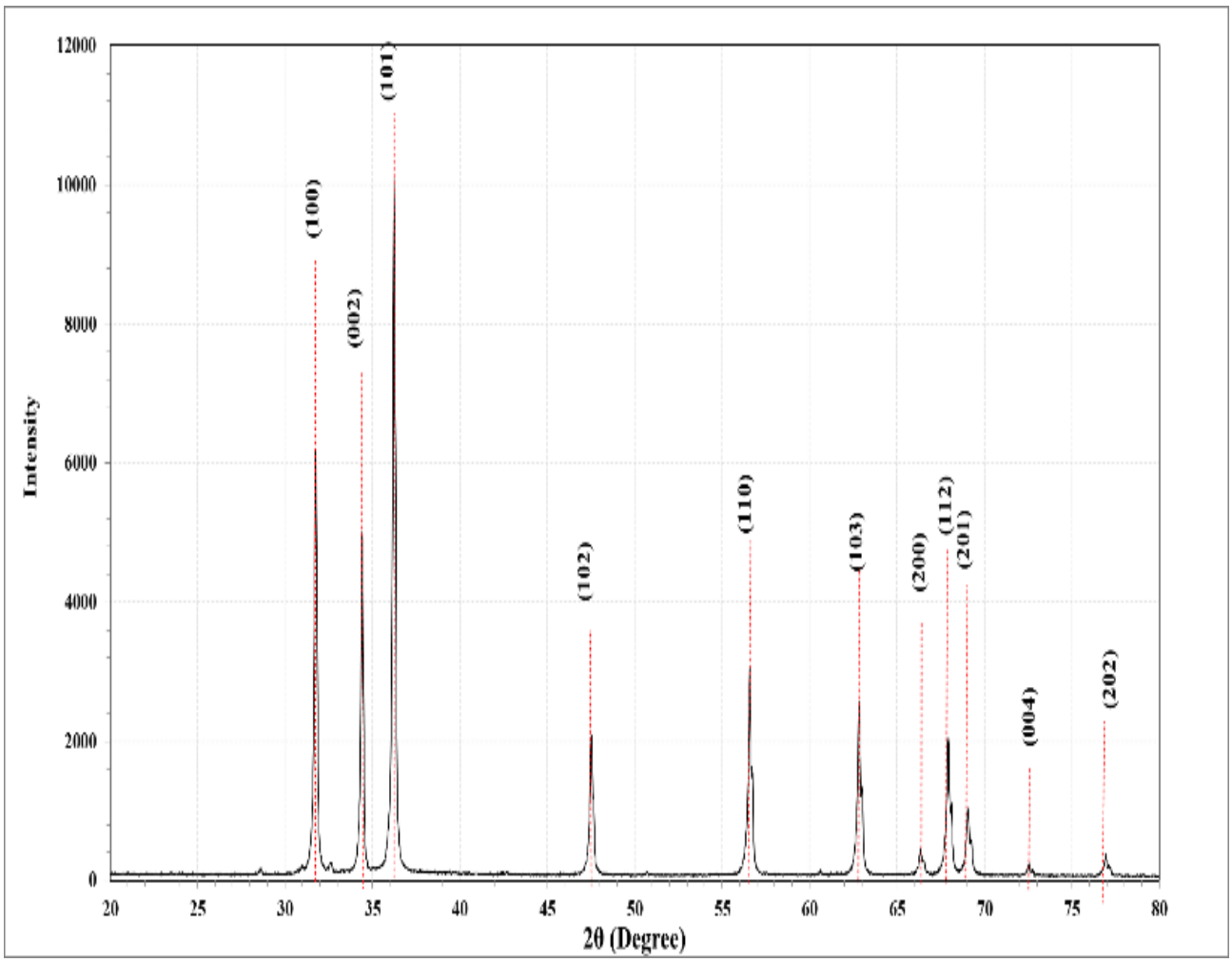


Figure 1. The X-ray diffraction diagram of ZnO powder

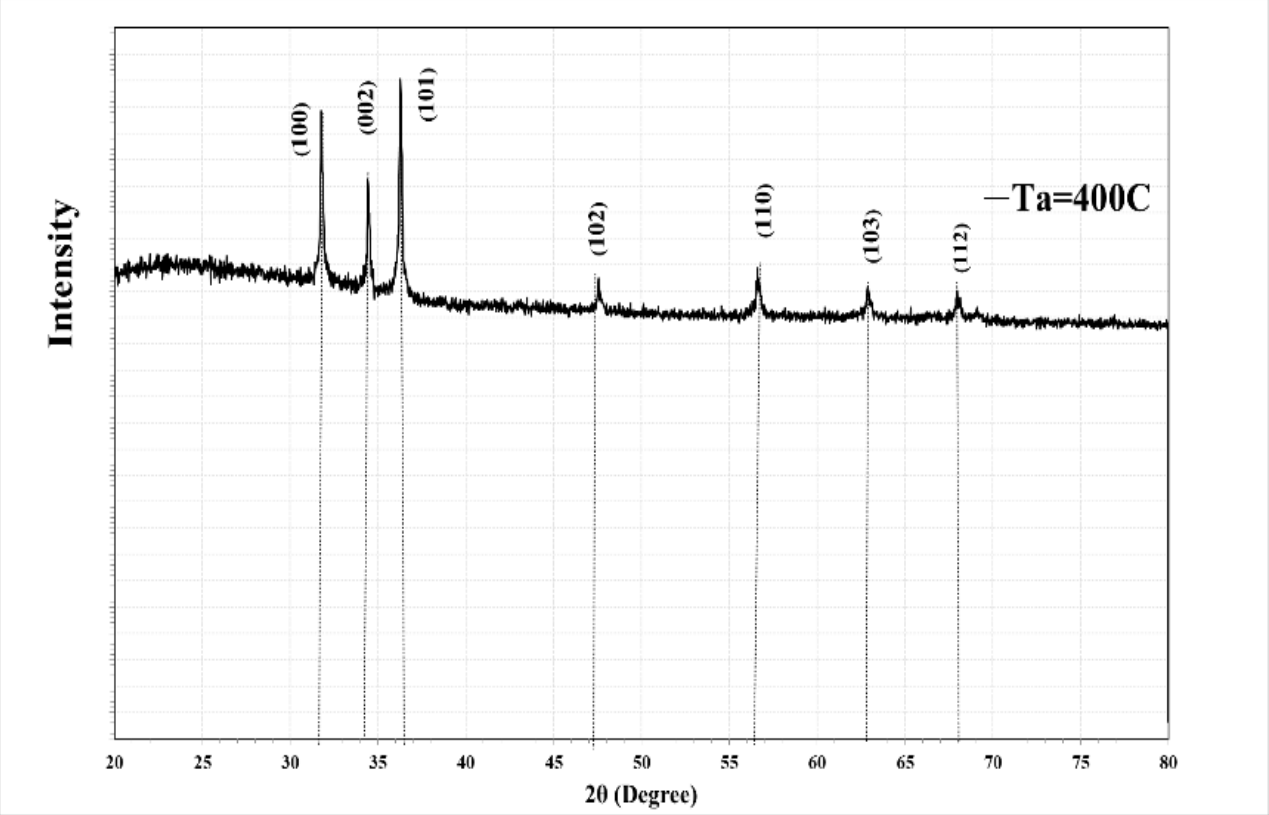


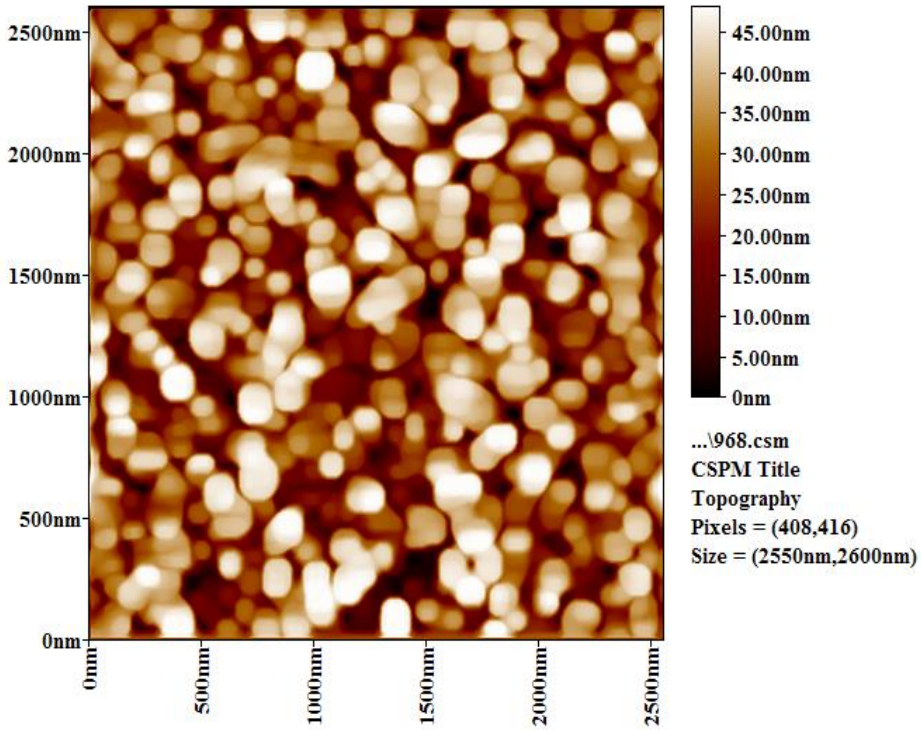
Figure 2. X-ray diffraction diagram of the annealed ZnO membrane at 400oC

We notice the emergence of a number of peaks such as (100) (101) (002) (110) of the membrane after annealing at (400oC), which preserved the crystalline nature [8]. Through the following table, we notice the difference in the size of the granules for each growth direction, but the largest size is at the growth direction (100) (102) (101), and we also note the FWHM values that the smallest value is at the growth direction (100) [9].

Table 1. Results of XRD examination of the plasticized ZnO film at 400oC

T (C)	2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp.(Å)	G.S (nm)	hkl	d_{hkl} Std.(Å)
	31.7688	0.1751	2.8144	47.2	(100)	2.8137
	34.4308	0.2101	2.6027	39.6	(002)	2.6035
	36.2522	0.2102	2.4760	39.8	(101)	2.4754
400	47.5657	0.2102	1.9101	41.3	(102)	1.9110
	56.6025	0.2802	1.6247	32.2	(110)	1.6245
	62.8722	0.3152	1.4770	29.5	(103)	1.4772
	66.6200	0.5254	1.4027	18.1	(200)	1.4069
	67.9860	0.3853	1.3778	24.9	(112)	1.3782
	69.1068	0.3853	1.3581	25.0	(201)	1.3582

The figure shows the results of the AFM assays of the annealed ZnO membrane at 400oC



The table shows the results of the AFM assays of the plasticized ZnO film at 400°C

Temperature	Average Diameter (nm)	RMS roughness (nm)	Peak-peak (nm)
673K	91.34	11.9	48.1

Conclusions

Where we note from it that the average grain size is less than 100 nm [10], which gives the membrane nanoscale properties that help in increasing the effectiveness of the biological application of the membrane.

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