Synthesis and Characterization of Nanoparticle Semiconductor Materials (ZnO) by Hydrothermal Technique

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Abstract: - ZnO nanoparticles have been synthesized by the Hydrothermal technique of [Zn(CH3COO)2 2H2O] solution by ethanol within NaOH. The samples have been characterized by an X-ray diffraction study. Field emission Scanning electron microscopy reveals the nanostructure of the particles produced. their crystal size ranges in the range of nm (74-94 nm) and changes to(53-59 nm) under change of the time preparation.

Keywords: - Hydrothermal technique, nanoparticle, X-ray diffraction, Fesem, Semiconductor Materials, crystal size. chemical synthesis.

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1 Introduction

For a long time, nanomaterials abroad have been of interest in research and development activities. Nanomaterials are of interest for their optical, electrical, and other properties. These properties have the potential to have incredible effects on electronics, medicine, space exploration, and other fields [1]. Nanomaterials are characterized by a group of materials (crystalline or amorphous) from natural or inorganic materials with sizes in the range of 1-100 nanometers. Nanomaterials are categorized into nanostructures, nanoscale, and nanoparticle materials [2]. For this to happen, the melting temperature of gold nanoparticles is much lower than 300 degrees than the melting temperature of a gold nugget [3]. Nanomaterials are the building materials for the twenty-first century and its building blocks and the most important pillars of technologies (nanotechnology, biotechnology, information, and communication technology), a standard for the progress and civilization of nations and an indicator of their rise. Nanomaterials differ according to the source, as they differ according to their proportions, such as being organic or inorganic, natural or synthetic. All known engineering materials such as metallic elements and their alloys (metals and metal alloys), semiconductors, oxides, and metals, as well as in this century enhance performance in a unique and unprecedented way [4]. Zinc oxide has gained great interest in the scientific and medical communities, due to its important use in many biomedical and antibacterial applications, due to its chemical and physical properties , such as a high electrochemical correlation coefficient and high photochemical stability. Zinc oxide is classified as a group II-VI semiconductor between ionic and covalent semiconductors, zinc oxide can be found in one-dimensional, two-dimensional, and three-dimensional structures and the structures are more one-dimensional than others. ZnO shows wurtzite (hexagonal symmetry) or (cubic symmetry) rock salt structure, but ZnO crystals are more common and stable with wurtzite ZnO is an excellent oxide semiconductor with a wide direct bandgap of 3.37 eV and a large exciton binding energy of 60 meV at room temperature [5]. Zinc oxide is one of the most widely used semiconductors in various fields such as flat displays, electroacoustic devices, and photocatalysis. Zinc oxide is a wonderful material with multiple properties suitable for high technology such as light-emitting diodes, photodetectors, chemical and biological sensors, and energy collectors including solar cells, nanogenerators, electromagnetics, etc. due to its high chemical and thermal stability, electronic and optoelectronic properties. Zinc oxide belongs to the hexagonal crystal system. Zinc and oxygen join a tetrahedron centered on a common zinc atom to form an additional tetrahedron core, resulting in the development of a wurtzite-type crystal lattice. ZnO material has attracted more and more attention during the past few years due to these applications in various fields [6]. It includes properties such as a strong oxidizing ability to degrade organic compounds [7]. Then after that, a great abundance of works that in a great picture, in the light of some things that in ultraviolet light. Solar Energy Efficiency, Household Materials Research on Energy ZnO Photocatalysts. To date, various shapes of ZnO powders include prismatic, elliptical, pyramidal, dumbbell-like, flower-like, nanowire, nanorod [9], nanotubes, nanoshells [10]. They were prepared by different syntheses of different preparation conditions [10]. To synthesize ZnO semiconductors, Several wet chemical methods are available for the synthesis of ZnO nanomaterials such as spray pyrolysis, hydrothermal, thermal solvents, sol-gel Precipitation, and combined precipitation. The hydrothermal method is widely used because it avoids it. Toxic and expensive solvents for preparing crystal oxide materials. To me Preparation of oxide nanoparticles, usually three methods are included, such as hydrolysis, Oxidation, and thermal decomposition. All this is done under hydrothermal conditions thermal water. The method is a promising method for the synthesis of high purity materials with control of homogeneity. various methods have been used, including the natural method, the physiotherapy method and the ultrasound method, the direct heating of the salt precursor, the organometallic synthesis method, and the hydrothermal method [10]. Because of its diverse properties, both chemical and physical, zinc oxide is widely used in many areas. It plays an important role in a very wide range of applications, ranging from tires to ceramics, from pharmaceuticals to agriculture, and from paints to chemicals [10]. The mechanical properties come on top of the properties that benefit from the reduction in the size of the particles of the material and the presence of large numbers of atoms on the faces of its outer surface, where the degree of hardness of metallic materials and their alloys increases, and their resistance increases to face the stresses and loads on them, and ceramic materials are given a great deal of strength, formability, and endurance. Stresses were not available, and this means the synthesis of new types of these materials [11]. This research aims to study the structural properties and surface properties and their effect on the rest of the properties, including the mechanical properties, and benefit from them in mechanical engineering.

2 Experiment Setup

The materials that were prepared during the winter season have been prepared, were dissolved in 1.5 g of [Zn(CH3COO)2 2H2O] in 25 ml of ethanol and 25ml of DDW for 15 min using a magnet. 1g of NaOH was obtained at the same time. NaOH solution was added dropwise to the aqueous [Zn(CH3COO)2
2H2O] solution. Under stirring for 20 min at 25ºC to produce a white gelatinous deposit. It was in an autoclave and placed in an oven at 160°C for (5 and 6 h). A precipitate is formed at the bottom of the autoclave and allowed to cool naturally to 25ºC. The obtained precipitate was centrifuged and rinsed with distilled water and ethanol three times to remove the sodium salt, the product was dried at 60 °C for 45 min with a hot plate to obtain ZnOnano-powder. Zn(CH3COO)2.2H2O + 2NaOH
Zn(OH)2 + 2CH3COONa + 2H2O
It was sealed in an autoclave and placed inside the muffle furnace at a temperature of 160ºC
for 5 hours. A precipitate was formed at the bottom of the autoclave and it was allowed to cool toroom temperature naturally. The obtained precipitate was centrifuged and thoroughly rinsed withdistilled wat er and ethanol three times to
remove the residual sodium salt CH3COONa.

3 Results and Discussion

3.1. X-Ray

The XRD patterns of ZnO nanostructure film was shown in figure (1),(2) and table (1). The XRD of the synthesized zinc oxide shows broad peaks at values of 31.9, 34.5, 36.3, 56.7, and 62.9 which are typical for the zinc oxide structure. Notable line broadening of the diffraction peaks is an indication that the synthesized materials are in the nanometre range. The average particle size has been determined from the full width at half maximum (FWHM) of the diffraction peaks . The average particle size of zinc oxide nanoparticles is 9 nm. All the diffraction peaks of the samples can be indexed to the hexagonal phase of ZnO (JCPDS 36-1451), and no other crystalline phases were detected, CrystalSize was calculated from the Scherer formula

$$D=K\,\lambda/\,\beta\cos\theta \qquad (1)$$

when D: is the grain size, λ: is the wavelength of Cu K (1.5406 Å), β: full width at half. XRD was investigated for the crystalline purity

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of ZnO with a Bruker Xray diffractometer (Model AXS D8 Advance using Cu Wavelength1.5406 nm).

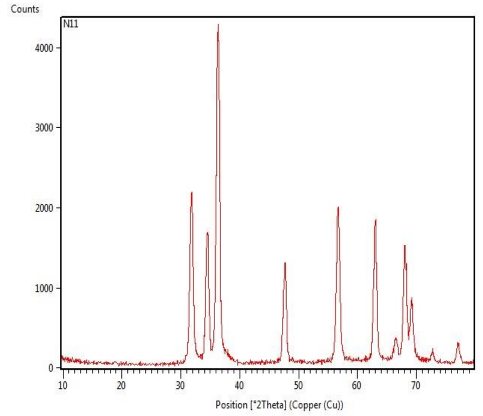


Fig. 1: X-ray diffraction spectrum of ZnO Nanomaterial In 160°c and 5h.

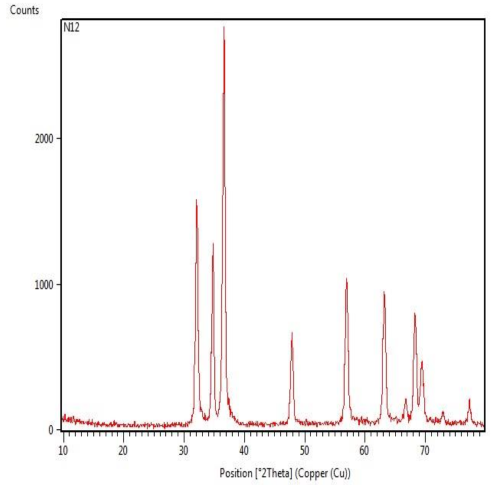


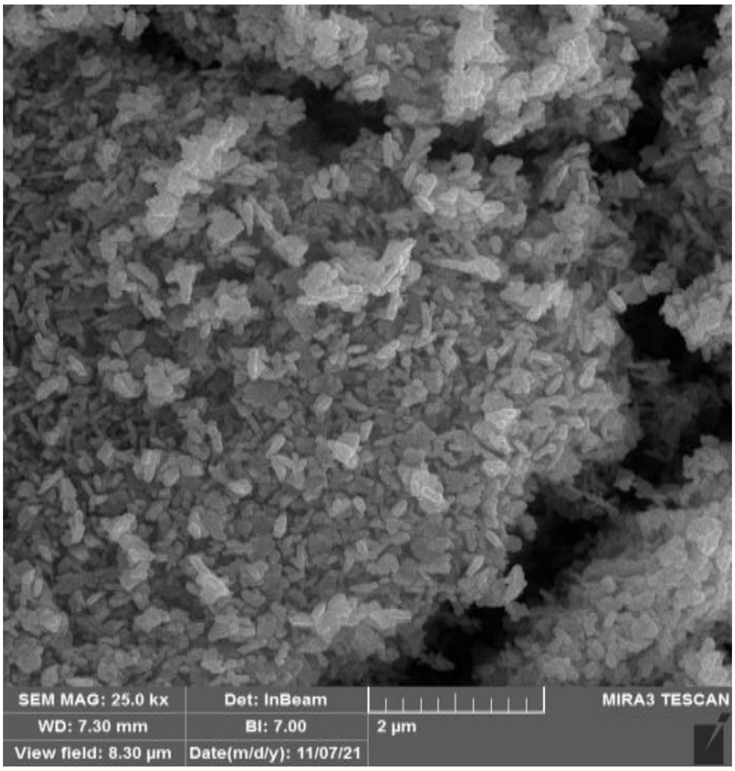
Fig. 2: X-ray diffraction spectrum of ZnO nanomaterial in 160°c and 6h.

Table 1. X-ray diffraction variables of ZnO nanomaterial.

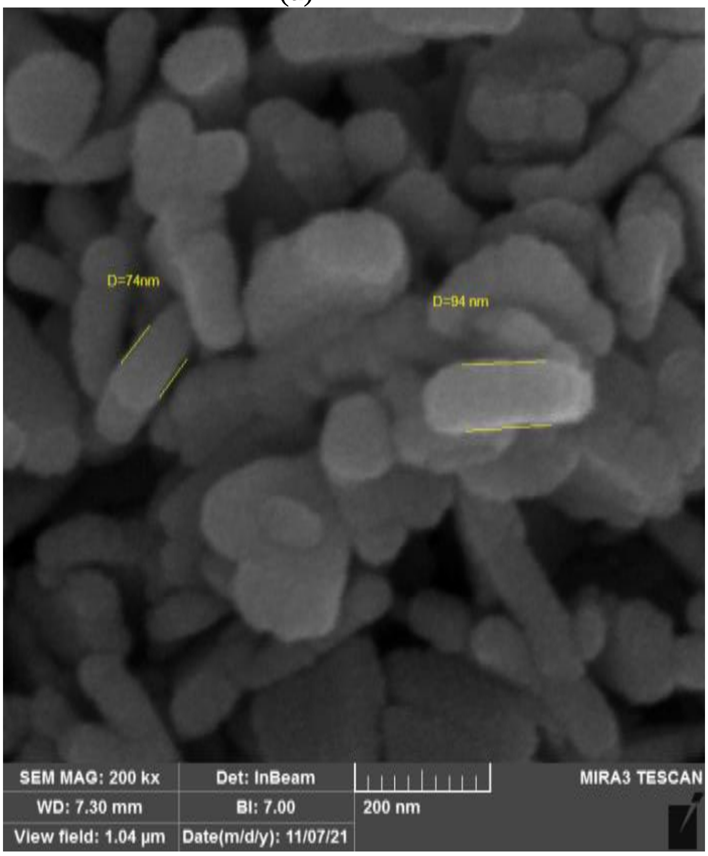
2θ	θ	FWHM	Crystal size(nm)	intensity	d-spacing(A°)	Miller index
31.85	15.92	0.5197	7.94	639.43	2.80	(1 0 0)
34.52	17.56	0.5197	8.01	516.64	2.59	(0 0 2)
36.33	18.16	0.5197	8.04	1000	2.47	(1 0 1)
47.64	23.82	0.5197	8.35	208.27	1.90	(1 0 2)
56.71	28.35	0.5197	8.68	340.76	1.62	(1 1 0)
62.96	31.48	0.5197	8.95	259.39	1.47	(1 0 3)
66.40	33.2	0.5197	9.13	45.81	1.40	(2 0 0)
68.01	34.0	0.5197	9.21	253.64	1.37	(1 1 2)
69.11	34.55	0.5197	9.27	112.77	1.35	(2 0 1)
72.47	36.23	0.5197	9.47	19.65	1.30	(0 0 4)
77.47	38.53	0.5197	9.76	32.33	1.23	(2 0 2)

3.2 Field Emission Scanning Electron Microscope

The Fesem scanning of the prepared Zinc Oxide particles as shown in Figures (3) and(4) showed that they have a nano-rods shape and the particles are lumpy, regular in shape, with an average size of particles nm (94 nm) and their crystal size ranges in the range of nm (74-94 nm) and change to(53-59 nm) under change of the time Preparation. The morphological features were recorded by FESEM(Hitachi S-4700) with an accelerating Voltage of ~50kV and elemental composition was obtained using an energy-dispersive X-ray spectrometer (FEI Philips XL).



(a)



(b)

Fig. 3: Shows the FESEM of the ZnO nanomaterial in 160ºc and 5h in (a) 2 μm, (b) 200 nm

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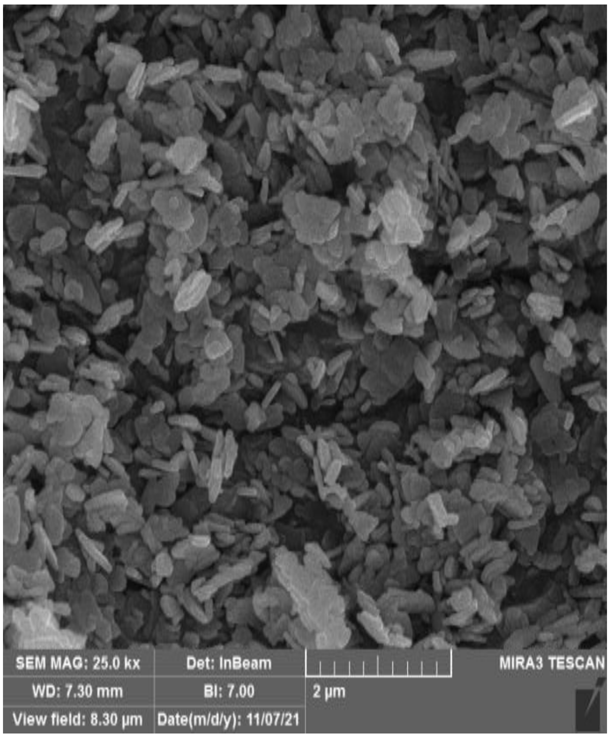

(a)

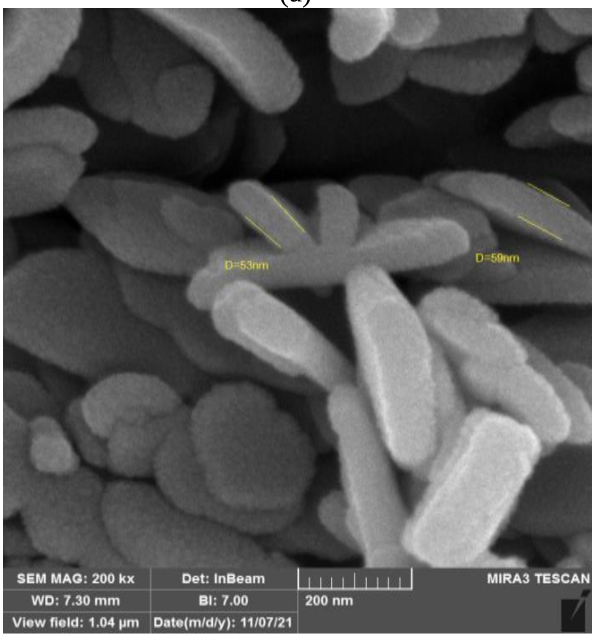

Fig. 4: Shows the FESEM of the ZnO nanomaterial in 160ºc and 6h in (a) 2 μm, (b) 200 nm.

4 Conclusions

ZnO nanostructure thin films have been successfully synthesized on FTO substrate by hydrothermal method. It is fast, clean, with an extended period of stability, and cheap. It is a better method to provide metallic oxide. The structural and morphological, the shape is nano-rods and the particles are lumpy, regular in shape, with an average size of particles nm (94 nm) and(59 nm) their crystal size ranges in the range of nm (74-94 nm) and change to(53-59 nm) under change of the time preparation. According to the XRD characterization, the average particle size of zinc oxide prepared using Scherrer's equation. The average particle size of zinc oxide nanoparticles is 9nm

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