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Research Article

Structural, Morphological and Optical Properties of Electrochemically Synthesized Al_2O_3/ZnO Nanocomposite

Wisam Taher Muslim [1], Zahraa Kadhim Abbas [2], Hasan R. Hammood [3*], Munaf M. Naji [4]

[1,4] Department of Clinical Laboratory Science, Faculty of Pharmacy, Kufa University, Najaf, Iraq

[2] Department of Pharmacy Techniques, Technical Institute, Kufa, Al Furat Al Awsat Technical University, Najaf, Iraq

[3] Department of Plant Protection, College of Agriculture, Kufa University, Najaf, Iraq

Corresponding Author: *Hasan R. Hammood

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Abstract

In the present era, nanomaterials have many uses due to their superior chemical and physical characteristics. The electrochemical deposition approach, which is quick, simple, and affordable, is one of the key techniques for creating nanocomposites (Al_2O_3/ZnO). Advanced methods like X-ray diffraction (XRD), field-emitted scanning electron microscopy (FESEM), microscopy using transmission electrons (TEM), ultraviolet-visible (UV-Vis), energetic dispersive x-ray (EDX), and atomic force microscopy, also called AFM, are used to analyse the nanocomposite. According to the investigation, the nanocomposite had an average crystal size of 8.4 nm, a band gap value of 3.23 eV, and a nanorod form.

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1. INTRODUCTION

The nanoparticles of metal oxide are characterised by superior stability, lower toxicity than other materials, high immovability, and higher selectivity than other related organic compounds [1]. The particle size plays important role in the chemical and physical properties of materials when converted to the nano scale. These nanomaterials, due to their size particles show remarkable uses in different fields such as drug delivery, catalysis, treatment of water, semiconductor materials, sensor gadgets, and solid oxide fuels [2]. The main advantages of these materials are: -the surface properties change in that band gap that led to a change in the conductivity and chemical reactivity; - the qualities of electrochemical changes due to the influence of quantum regulation; - changes in the structure that permit the modification of structural symmetry as well as cell parameters [3]. Materials classified by their various components are called composites. One such composite includes sections and lists, which can significantly increase the number of people accessing them. These composites have a diameter greater than 100 nanometers and are called flat matrix composites [4]. A nanocomposite is an electrically conductive, tall, mechanically robust, less irritating, and bonded composite material, intended for devices, etc., and is a new type of composite material. The institutionalisation of such devices combines environmental friendliness and cohesion, with high regeneration and renewal, while maintaining the highest quality standards [5]. The sheer volume of unique microcomposites. Pure water, supercapacitors, electrically conductive structures, corrosion inhibitors, anti-static photovoltaics, photonic elements, nature, biosensors, biomaterials, and bioenergy – all are available within a few kilometres, under any conditions, and can be detonated. Nanoparticles/polyaniline (AgPani) eliminate aniline scratch residues on-site to obtain a better atom at 265°C. Well, you can use additional biosensors, or even then, this is the case with electric water heating technology [6]. The use of bio composites in the best technological additions, such as bioanalysis and basic biosensor detection, is powerful for the largest chain [7].

2. MATERIALS AND METHODS

2.1 Materials

97% aluminum foil, zinc foil, and polyvinyl alcohol (Fluka, Germany). Graphite, 99% ethanol, 98% acetone, 97% polyethylene glycol, 95% potassium chloride, and 97% potassium iodide (CDH, India). 99% iodine (Thomas Baker, India).

2.2 Methods

2.2.1 Preparation of Al_2O_3/ZnO Nano composite.

An inert electrode made of graphite and a working electrode constructed of aluminium and zinc foil were used to make the Al_2O_3/ZnO Nano composite using the electrochemical technique. A power supply is also utilised. Acetone and ethanol were used to wash the cathode and anode, followed by deionised water [8]. A 200 mL solution containing 5 mL of 10 g/100 mL electrolyte (KCl) and 10 mL of 10 g/100 mL stabiliser (polyvinyl alcohol (PVA) and ionised water, respectively) is poured into the electrochemical cell. Zinc foil (0.5 cm x 4 cm) and aluminium foil (0.5 cm x 4 cm) make up the working electrode, which is placed face-to-face with a graphite electrode (2 cm x 5 cm) in the cell electrolyte [9]. At a temperature of less than 30°C, the electrolysis process was carried out in an undivided electrolytic cell for sixty minutes while stirring. The voltage ranges from 9 to 15 volts. After removing the white precipitate resulting from Al2O3/ZnO and washing it again with ethanol and deionising water, it was transferred to a drying vessel, dried for 60 minutes at 60 °C, and then calcined for 60 minutes at 700 °C [10].

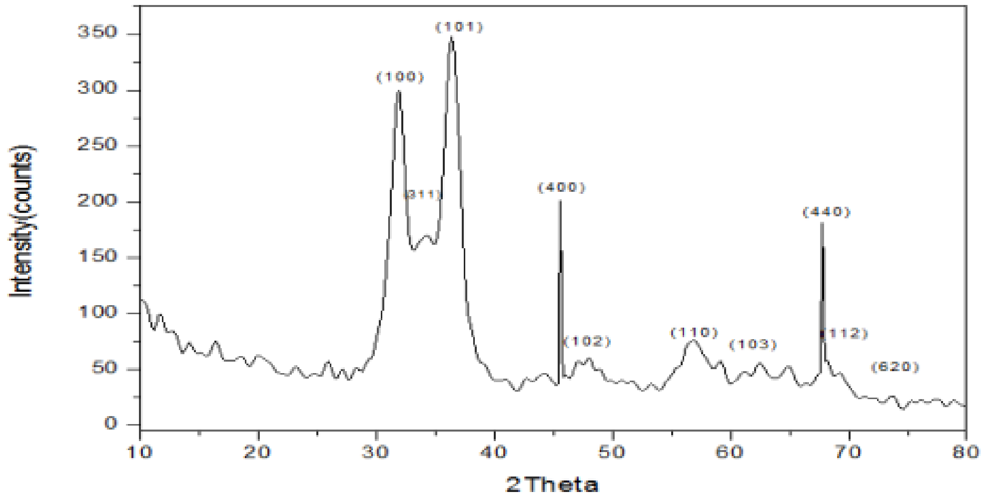
Figure 1: The Al_2O_3/ZnO Nano composite is prepared using an electrochemical method.

3. RESULTS AND CONVERSATIONS

3.1 Al_2O_3/ZnO Nanocomposite X-Ray Diffraction Analysis.

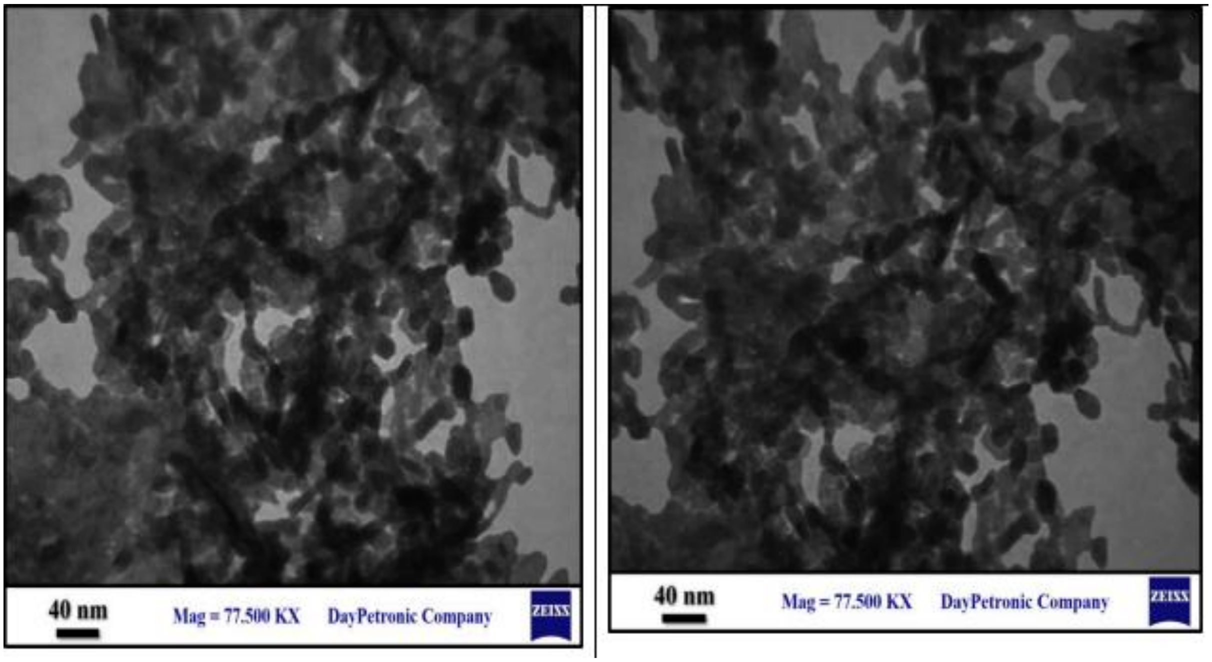
Ringenowski diffraction of the Al_2O_3/ZnO fine-tuning enhances the extreme temperatures required for optimal electrochemical reactions. The electrochemical spectrum minimises the interference pattern of Al_2O_3/ZnO. Ringenowski diffraction exhibits greater interference than that found in single-atom Al_2O_3/ZnO diffraction, and the maximum isolating capacity is minimised to prevent interference from becoming more pronounced. Furthermore, these snapshots are very intense, as shown in Resonke 2. Some neutral snapshots show hardening at 2θ (32,023°, 36,856°, 48,352°, 57,320°, 63,253° to 69,643°) direct Miller index (100), (101), (102), (110), (103) to (112) refined zinc oxide, to 35,972°, 46,860° to 74,784°) standard Miller index (311), (400), (440) to (620) enhanced Al2O3. The best PIC in all large diffraction, improved diffraction intensity, and enhanced. All the bikinis and vibrant $Al_2O_3$are sent to an effective Al_2O_3/ZnO nanocomposite, a new nuclear material. [11].

Figure 2: The Al_2O_3/ZnO Nano composite's X-ray diffraction pattern.



3.2 Al_2O_3/ZnO Nano Composite Analysis Using Transmission Electron Microscopy (TEM). Figure 3 displays TEM micrographs of Al_2O_3/ZnO nano-composite that were produced electrochemically at room temperature. The electrochemically produced Al_2O_3/ZnO Nano composite crystalline forms have a nanorod shape, according to the TEM data [12].

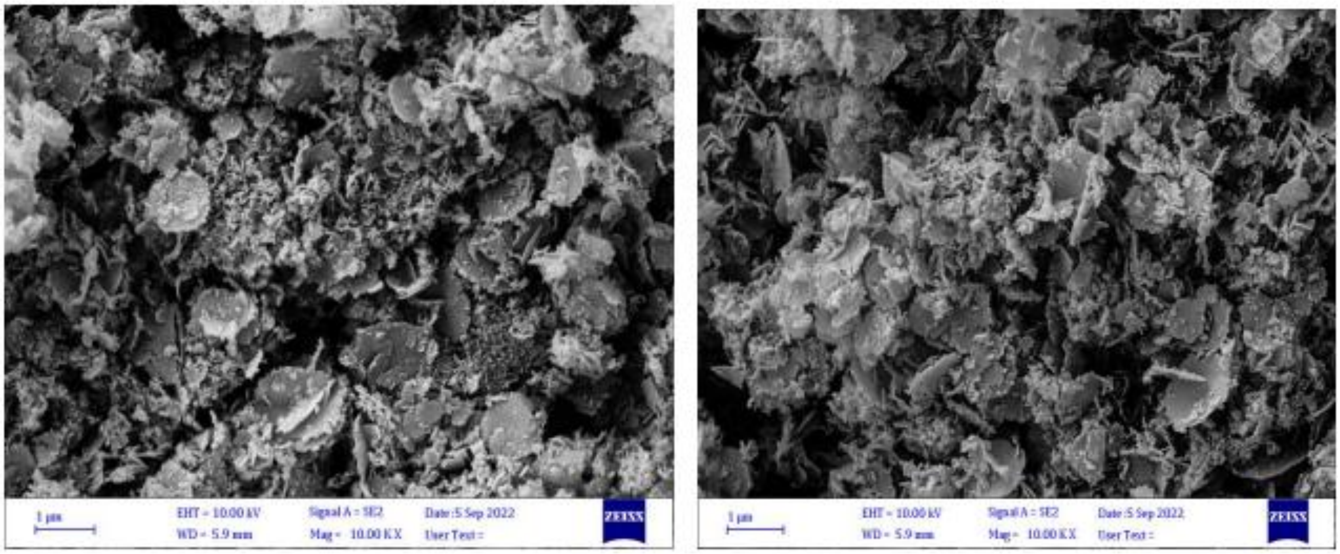
Figure 3: TEM images of Al_2O_3/ZnO Nano composite.



3.3 The Al_2O_3/ZnO Nano composite Field Emissions Scanning Electron Microscope (FESEM).

Field-emission scanning electron microscopy (FESEM) is used to determine the shape and structure of the prepared films. FESEM in secondary electron mode, with 100,000x magnification and an operating voltage of 10 kV, can produce high-resolution images of the sample surface. The particle arrangement is clearly visible in the FESEM image. As shown in Figure 4, the outer layer of the Al2O3/ZnO composite is characterised by a complete and homogeneous coating of dense nanosheets, bonded together to form a three-dimensional porous structure. The Al2O3 nanoparticles are essential for the formation of the Al2O3/ZnO composite, as they not only provide structural support for the ZnO nanoparticles but also prevent their agglomeration [13].

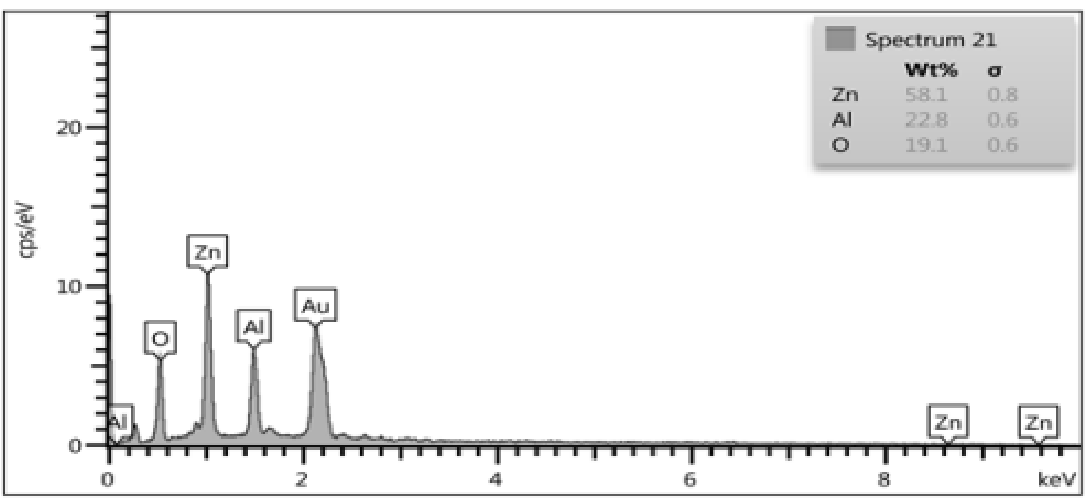
Figure 4: FESEM images of Al_2O_3/ZnO Nano composite.



3.4 Al_2O_3/ZnO Nano composite Energy Dispersive X-Ray Spectroscopy (EDX).

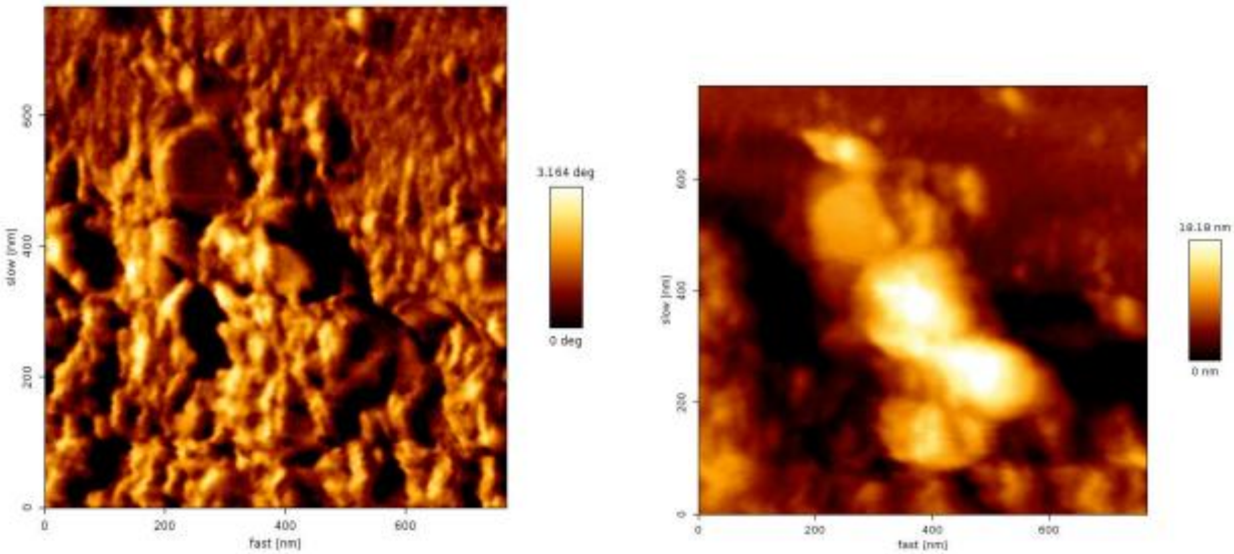
Energy dispersive X-ray spectroscopy (EDX) was used to assess the purity and stoichiometry of the electrochemically produced Al_2O_3/ZnO Nano composite. The results, which are displayed in Figure 5, demonstrate that the samples were extremely clean because only particular signals for oxygen, Aluminium and zinc were present. As can be observed in the EDX chart for ZnO NPs, the appearance of gold in the chart is a result of gold covering the sample during testing. Zn=58.1%, Al=22.8%, and O=19.1% are the weight proportions of Al_2O_3/ZnO. These ratios show that the ZnO: Al_2O_3ratio is 2:1, in conjunction with the presence of free metal deposits of zinc and aluminium that function as doping [14].

Figure 5: Al_2O_3/ZnO Nano composite's EDX spectrum.



3.5 Analysis of the Al_2O_3/ZnO Nano composite by Atomic Force Microscopy (AFM). Topographic imaging using atomic force microscopy (AFM) is an effective method for gathering detailed information about the morphology, topography, and texture of various surfaces. Weak structures are represented by muted colours in AFM images, while strong structures are represented by bright colours due to the different orientation of the particle grains. Among the many important properties included in the comprehensive data obtained from AFM measurements are surface asymmetry, mean square root ratio, and mean surface roughness (Sa). On the other hand, AFM measurements provide excellent information about the mean diameter of nanoparticles, their size dispersion, and their surface homogeneity [15]. Figure 6 shows how an Al2O3/ZnO nanocomposite can be used to create two-dimensional (D) and three-dimensional (3D) images and configurations.

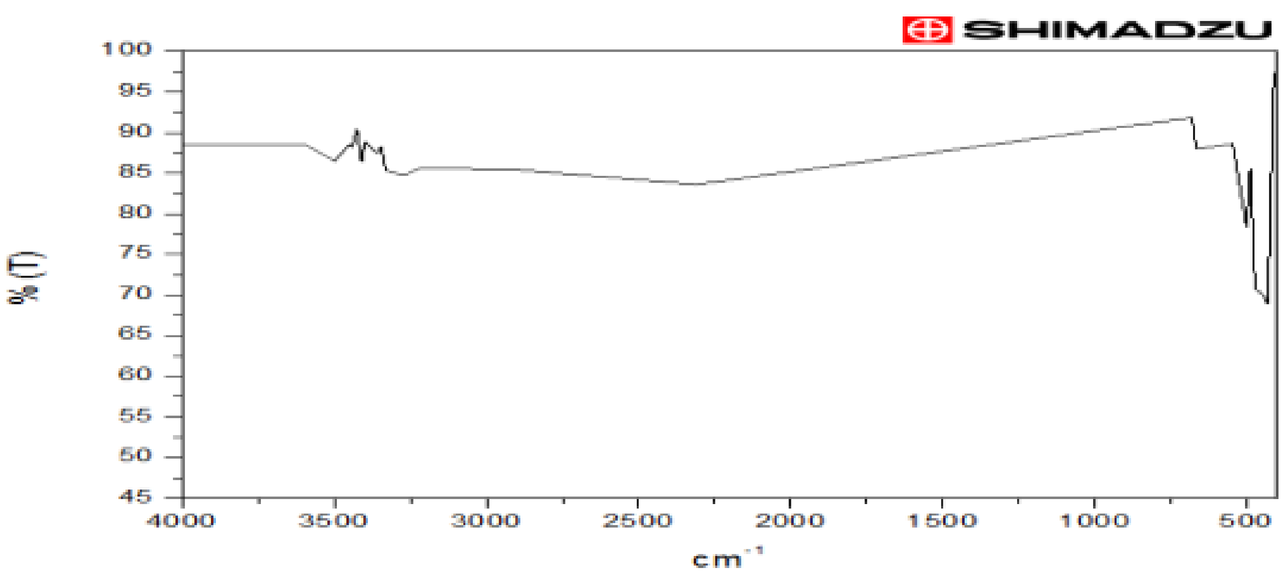
Figure 6: Al_2O_3/ZnO Nano composite AFM 2D and 3D pictures



3.6 Al_2O_3/ZnO Nano composite Fourier transformation infrared spectroscopy analysis (FT-IR).

FTIR spectroscopy was employed to get additional insight into the chemical relationship between Al_2O_3NPs and ZnO NPs. The Al_2O_3/ZnO FTIR spectrum is shown in Figure 7. The presence of Al-O and Zn-O bonds was shown by the typical absorption peaks of the Al_2O_3/ZnO Nano composite that were mainly visible in the FTIR spectrum. The contraction vibration from Zn-O was linked to the peak at 464 cm, and the Al-O expansion mode was suggested by the stronger absorption at 500–750 cm-1 [16].

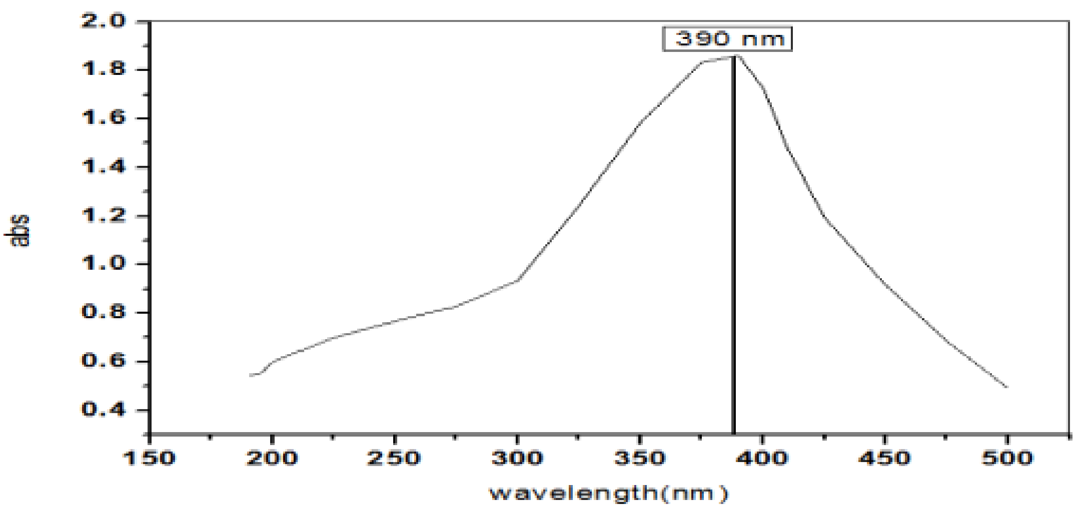
Figure 7: Al_2O_3/ZnO Nano composite FTIR spectrum; UV-Vis analysis of Al_2O_3NPs.



3.7 UV-Visible Spectroscopy (UV-Vis $Al_2O_3$and ZnO Nano Composite).

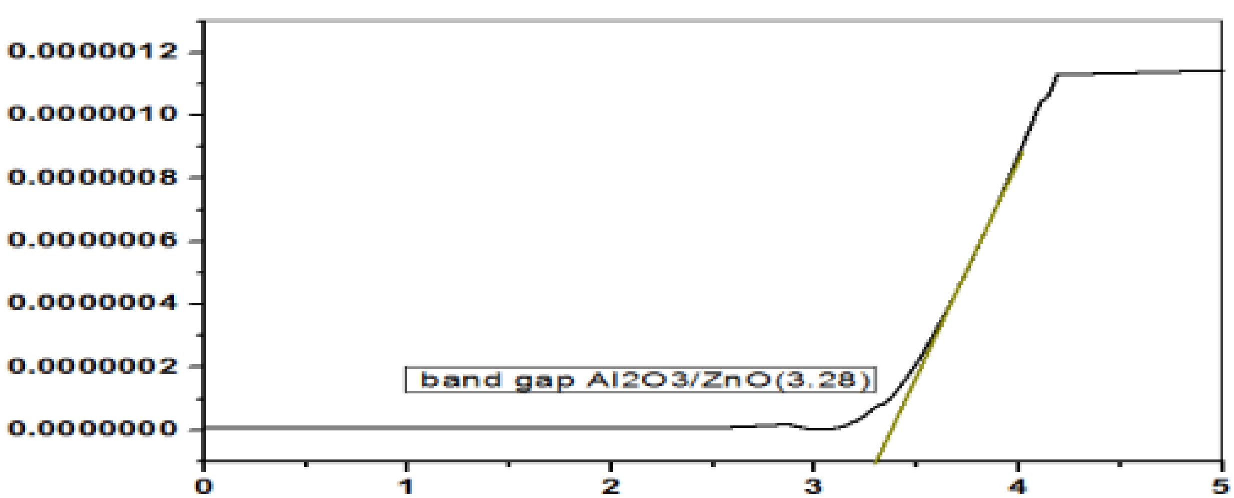
Solid state ultraviolet (UV)-visible spectroscopy was used to analyse Al_2O_3/ZnO composite thin films made on glassy slides at temperatures below 30 C^0. Figure 8 displays the generated UV-visible spectra, which seem to have a defined maximum wavelength [17].

Figure 8: Al_2O_3/ZnO Nano composite spectrum.



Furthermore, optical scanning is an important method for purifying crystalline and crystalline optical energy zones of non-metallic materials, indicating quality 9. A good optical zone type can be safe. The importance of basic sensitisation, equivalent to high-speed electronics from the zones, is what is called the wealth of love from the zone provision. All the necessary elements for this slip are an HF optical spectrometer. equipped with a matching spectrometer, good operation in the 150-500 nm range. The enhanced hydration lines (hv) and (α hv)2 on the graph, in addition to the clear optical vision zones, are a strong indicator. The properties that support Al2O3/ZnO in the field of optics at 25 slices of suitable pickup in the zone [18].

Figure 9: The optical band gap of Al_2O_3/ZnO Nano composite.



4. CONCLUSION

A straightforward and inexpensive electrochemical deposition technique was used to successfully create the Al_2O_3/ZnO nano-hybrid. The creation of a new composite material was verified by XRD structural characterisation, which showed peak shifting, intensity variations, and the emergence or disappearance of particular diffraction peaks. While FESEM pictures showed evenly distributed crumpled nano sheets producing a porous 3D structure, showing successful interaction between Al2O3 and ZnO nanoparticles, TEM investigation revealed that the nano-composite had a nano-rod shape. Energy- dispersive X-ray spectroscopy (EDX) verified a ZnO: Al_2O_3 ratio of roughly 2:1 and demonstrated the exceptional purity of the produced nano composite.AFM investigation also revealed a homogeneous surface with appropriate roughness and well-distributed nanoscale features. The presence of Al–O and Zn–O functional groups was confirmed by FT-IR spectroscopy, indicating effective bonding within the composite. Tauc plot analysis revealed an optical band gap of 3.23 eV, and UV-Vis measurements demonstrated a distinct optical absorption peak, indicating that the nano composite has promising optical properties appropriate for optoelectronic and photocatalytic applications. Overall, the study shows that electrochemical synthesis is an effective way to create high-quality Al_2O_3/ZnO Nano composites with desired structural, morphological, and optical characteristics that make them appropriate for use in advanced electronic devices, sensors, energy storage, and catalysis.

5. Conflict of interest. The authors declare that they have no conflict of interest in this article

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About the corresponding author

Hasan R. Hammood is associated with the Department of Plant Protection, College of Agriculture, Kufa University, Najaf, Iraq. His academic interests focus on plant health, pest management, sustainable agricultural practices, and crop protection strategies aimed at improving agricultural productivity and food security.