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STUDY CHARACTERIZATION PROPERTIES OF BIOSYNTHESIZED (SNO2/ZNO/TIO2) OXIDE

Ali Thajeel Azeez Hashi
Wasit University College of Science Department of Physics

Sajad Fadhil Mohamed
Wasit University College of Science Department of Physics

Abstract:

This study focuses on the biosynthesis and characterization of SnO_2/ZnO/TiO_2. Utilizing potato Extracted extract as a reducing agent, nanoparticles were synthesized via green methods, resulting in distinct structural and morphological characteristics. X-ray diffraction (XRD) confirmed the hexagonal structure of ZnO, tetragonal structure of TiO_2, and cubic structure of SnO_2 with average crystallite sizes of 16.41 nm, 22.68 nm, and 21.75 nm, respectively. Field Emission Scanning Electron Microscopy (FE-SEM) analysis showed nanoparticles with average sizes of approximately 35-36 nm. Energy-dispersive X-ray spectroscopy (EDX) confirmed the elemental composition of the synthesized nanoparticles. The biosynthesized nanocomposites exhibited promising structural properties

Keywords: Biosynthesis, Potato Extracted Extract, ZnO (Zinc Oxide), TiO_2 (Titanium Dioxide), SnO_2 (Tin Dioxide)

Introduction

Introduction

The continuous improvement of electronic components and sensors is required due to the progress in technologies that enable the digital distribution of environmental information. Gas sensors, solar cells, and photocells, as well as photocatalysts, are crucial components in this advancement, mostly utilizing semiconductor-based technologies. [1, 2]. Zinc oxide, tin dioxide, indium oxide, and titanium dioxide are the most often utilized compounds in affordable commercial sensors. These materials possess desirable qualities such as chemical stability, non-toxicity, and a strong capacity to withstand chemical changes when exposed to different gases. These characteristics make them attractive to both social and industrial concerns[3].This characteristic enables the introduction of impurities or heterojunctions, which allows for fine adjustment of their gas-sensitive properties [4, 5].

Recent research has focused on nanocomposite materials consisting of different proportions of ZnO and SnO2 oxides due to their outstanding gas-sensitive characteristics [6]. Nanocomposites are typically produced using several methods such as hydrothermal procedures, chemical technologies, electrospinning, atomic layer deposition, magnetron evaporation, and spray pyrolysis [5]. The production of a two-phase structure including ZnO and SnO2 oxides is ascribed to annealing temperatures below 600 ◦C, as proved theoretically. Temperature treatment is crucial for adjusting the functional characteristics of these oxides [7].

The investigation of the optical characteristics of ZnO-SnO2 composite films produced using magnetron sputtering demonstrated a band gap ranging from 3.3 to 3.32 eV. The exact value of the band gap depended on the precise technological protocols used. The concentration of tin ions is crucial in its activity as a modifying component for composite materials [7]. During the synthesis of SnO2-ZnO films using spray pyrolysis, it was noted that maintaining a maximum Sn ion concentration of approximately 8% is optimal for preserving the crystal characteristics. Increasing the concentration beyond 10% can lead to a degradation of the composite characteristics. In addition, when the concentration of Sn ions is increased to 6%, the band gap narrows to 2.72 eV [8].

The improvements in sensor qualities observed in nanocomposite materials can be linked to changes in the types of oxygen present on the surface and the combined effect of producing n–n heterojunctions, which leads to the construction of barriers that can affect the flow of electric current. [9] [10].

This literature review highlights the crucial importance of different levels of Sn content in ZnO-SnO2 films for adjusting their gas-sensing characteristics, highlighting the necessity for accurate technical procedures. The study suggests that a green-synthesis method using plant-extracted SnO2 and ZnO nanoparticles, applied through Spin coating and chemical bath deposition, could be a straightforward and economically feasible alternative for systematic exploration. This method may overcome the limitations of time and equipment cost associated with sol-gel methods and hydrothermal synthesis. The present work is to examine the influence of SnO2 additions in ZnO films with a 1:1 ratio manufactured using the spin coating process [11] [12].

Materials and Methods

Materials

Zinc, Tin and titanium precursor (Zinc chloride, Tin chloride and titanium chloride), Zinc chloride tetrahydrate (sigma Aldrich), Deionized distilled water (DDW), Tin (IV) chloride, pentahydrate (sigma Aldrich) Titanium (III) chloride solution (sigma Aldrich), potato Extracted, Glassware and laboratory equipment (beakers, stirrers, etc.).

Preparation of Materials

Preparation of potato Extracted Extracted Solution

Using a different, uncontaminated beaker, create a solution using potato Extracted. Obtained by precisely quantifying the intended quantity 200 grams of potato Extracted, chopped into little pieces. Add the required amount of deionized water to the beaker containing 200 grams of potato Extracted and 600 millilitres of water. Ensuring an optimal concentration of the potato Extracted solution. Allow the mixture to remain undisturbed for 12 hours at a temperature of 20 ℃.

Synthesis of Tin Oxide, Zinc Oxide and TiO2

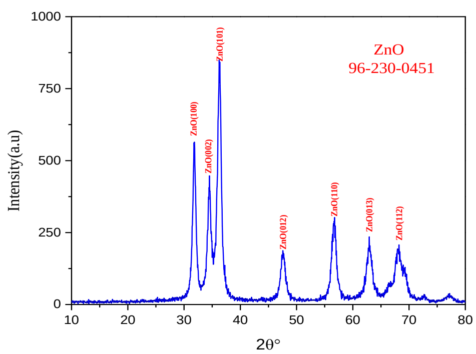
This laboratory technique employs a green synthesis method to generate nanoparticles of tin oxide (SnO_2), zinc oxide (ZnO), and titanium oxide (TiO_2) through a 1:1 mixture, using potato Extracted. Utilized as a reductive agent A solution of 0.5M Zinc chloride in 100 ml deionized water (DWW) was combined with solutions of 0.5M Tin chloride and 0.5M Titanium chloride in the same container. The mixture was agitated at a temperature of 50 degrees Celsius for 30 minutes, after which potato Extracted was added. Obtained approximately 40 millilitres of solution from the beaker. Observe any alterations in color or the creation of solid particles, which indicate the advancement of the reduction reaction. The stirring should be maintained for a suitable time of 30 minutes to ensure complete occurrence of the reduction process.

Results and discussion

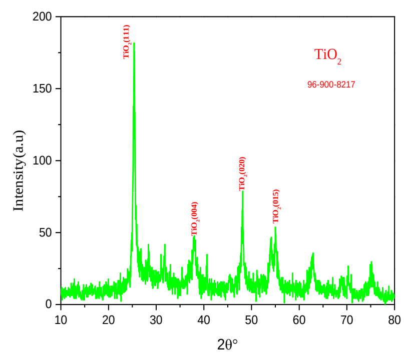
Structural, Morphological, Characteristics

The NPs/NCs generated utilizing green methods were analyzed for their structure using X-ray diffraction (XRD). Table (3) presents the structural characteristics of ZnO, TiO2, and SnO2 nanoparticles, while Figures (1), (A,B), and (C) display their corresponding X-ray diffraction (XRD) patterns.

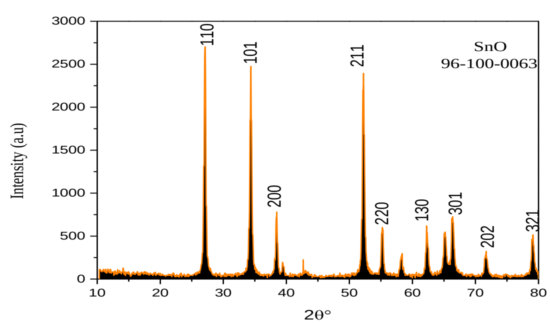
The most intense diffraction peaks for ZnO nanoparticles occur at 2-theta values of 31.811, 34.481, and 36.307, which correspond to the (100), (002), and (101) Miller indices. These peaks are in agreement with the hexagonal (Wurtzite-phase) structure, as indicated by the COD card number 96-230-0451. The average size of the crystallite is determined to be 16.411 nm[13]. The TiO2 nanoparticles exhibit distinct peaks at 2-theta values of 25.16, 37.359, and 47.635, which correspond to the (011), (004), and (020) miller indices, respectively. This confirms the presence of a tetragonal structure in the nanoparticles, specifically the Anatase phase (COD card number 96-900-8217). The mean size of the crystal grains is determined to be 22.687 nm [14]. The SnO2 NPs exhibit prominent peaks at 2-theta values of 27.09, 34.37, and 52.23, which can be attributed to the (110), (101), and (211) miller indices, respectively. These peaks suggest the presence of a cubic structure, as indicated by the COD card number (96-10-0063). The average size of the crystallite is measured to be 21.75 nm [15].



(A)



(B)



(C)

Figure 1 XRD pattern of (A) *ZnO*, (B) *TiO_2* and *SnO NPs*

Table 1 Structural properties of ZnO, TiO2, and SnO_2 NPs.

Sample	ZnO NPs			TiO_2 NPs			SnO_2 NPs		
Two θ (Deg.)	Strongest three peaks			Strongest three peaks			Strongest three peaks		
	31.811	34.481	36.307	25.16	37.36	47.635	27.09	34.37	52.23
hkl	100	002	101	011	004	020	110	101	211
FWHM (Deg.)	0.434	0.556	0.636	0.2826	0.4065	0.552	0.36	0.39	0.42
Crystallite size (nm)	19.879	15.625	13.729	30.083	21.547	16.431	22.78	21.31	21.16
Average Crystallite size (nm)	16.411			22.687			21.75		

Field Emission Scanning Electron Microscope (SEM)

The Field Emission Scanning Electron Microscope (FE-SEM) is an exceptionally potent instrument for analyzing nanostructures and nanomaterials. This is because it offers both high resolution and speed, allowing for direct measurement of the dimensions and forms of nanoparticles. The field emission scanning electron microscopy (FE-SEM) technique is used to analyze the properties of SnO2, ZnO, and TiO_2.

Figure 2 displays the FE-SEM picture of SnO2 NPs that were produced using green synthesis. These nanoparticles have an average size of approximately 35 nm and possess a spherical form. However, throughout their growing process, the SnO2 particles tend to agglomerate, resulting in bright patches as observed in Figure 2 ..[16]. The assembly of nanoparticles is hindered by their finite size, as the growth rate is dispersed evenly on all surfaces of the sample

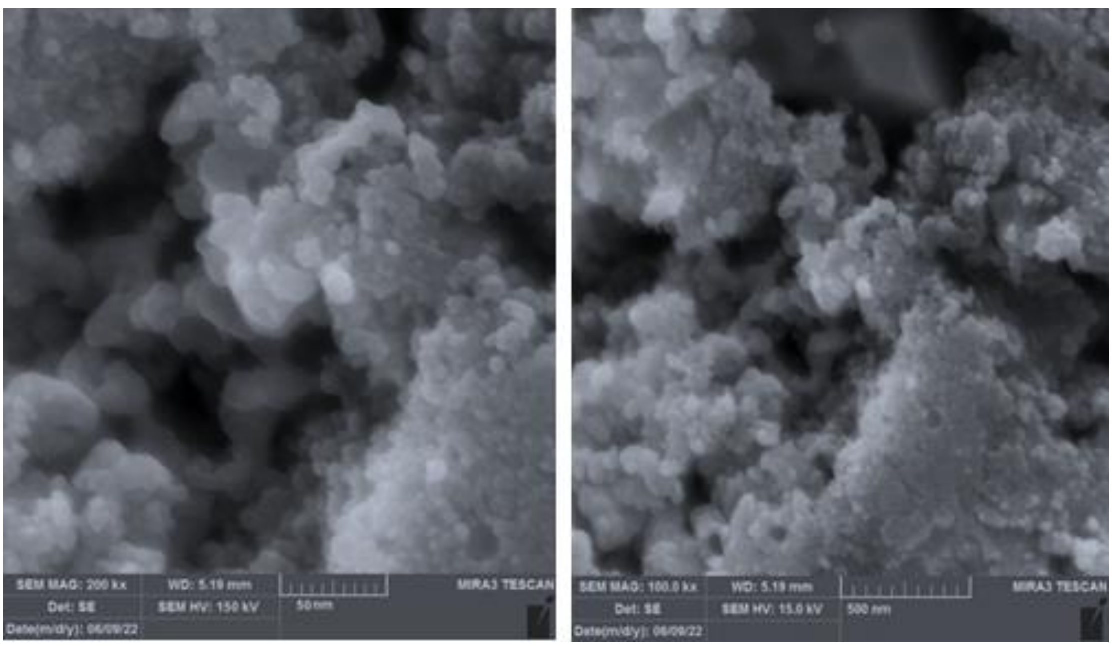


Figure 2 FE-SEM image of ZnO NPs

Figure 3 displays the FE-SEM image of TiO_2 NPs that were synthesized using a green method. These nanoparticles have an average size of approximately 36 nm and exhibit a particle shape characteristic of Anatase (tetragonal) growth. This particular shape is what sets Anatase (tetragonal) TiO_2 apart. The alteration of form has a broad impact on the alteration of physical characteristics in relation to the ratio of area to volume, as well as chemical characteristics in relation to the surface area of the reactant. Observe from Figure 1-6 that the surface area has expanded in relation to the volume.

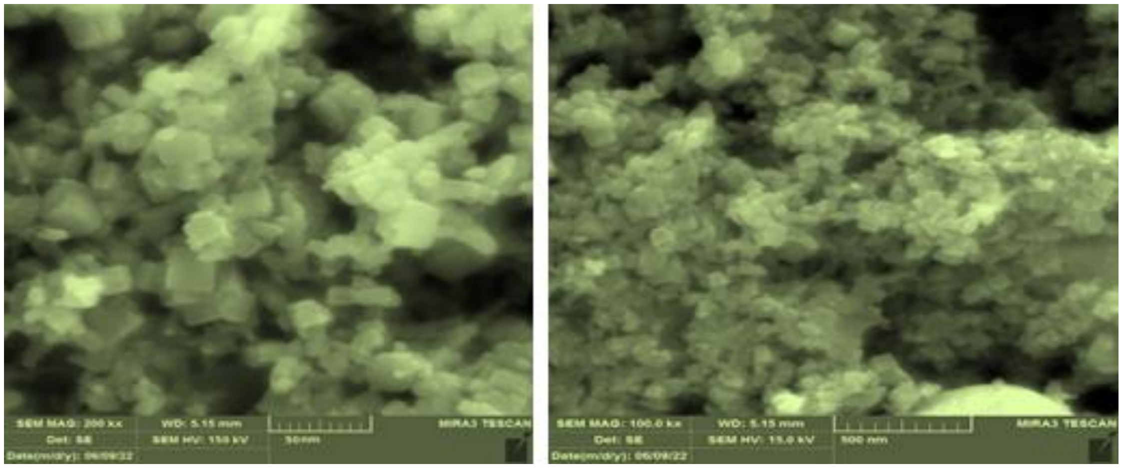


Figure 3 FE-SEM image of TiO_2 NPs

Figure (4) illustrates the SnO powder sample that was synthesized using the green approach. The sample is composed of rod-shaped microstructures with a surface that is reasonably smooth and uniform. These microstructures have a length ranging from 200 to 300 nm and a hexagonal cross-section with a diameter of 66 nm.

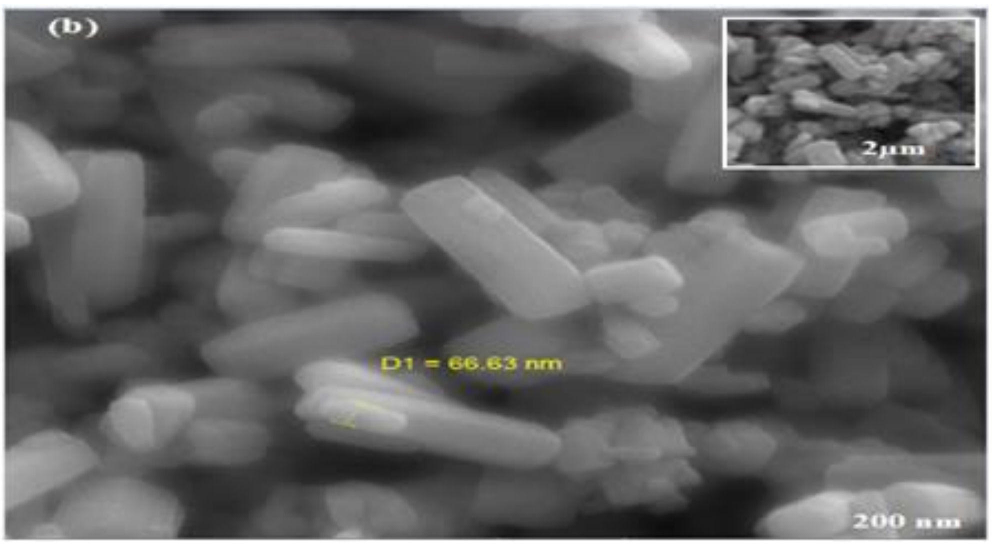


Figure 4 FE-SEM image of SnO NPs

The presence of hexagonal cross-section and precise dimensions of the rod-like structures suggest a synthesis process that is carefully controlled and can be replicated consistently. Various factors, including reaction conditions, temperature, reactant concentration, and the inclusion of specific organic compounds or plant extracts often employed in green synthesis, might influence the development of these unique microstructures.

EDS or EDX is an analytical method used to characterize a sample's chemical makeup or determine its elemental composition. The EDX technique was used in the current investigation to evaluate the NPs contents as well as any pollution that had been built up inside of them. Images from the EDX quantitative analysis of the samples are displayed in Figures 5,6 and 7 The purity of the SnO2, ZnO, TiO2, [17, 18]

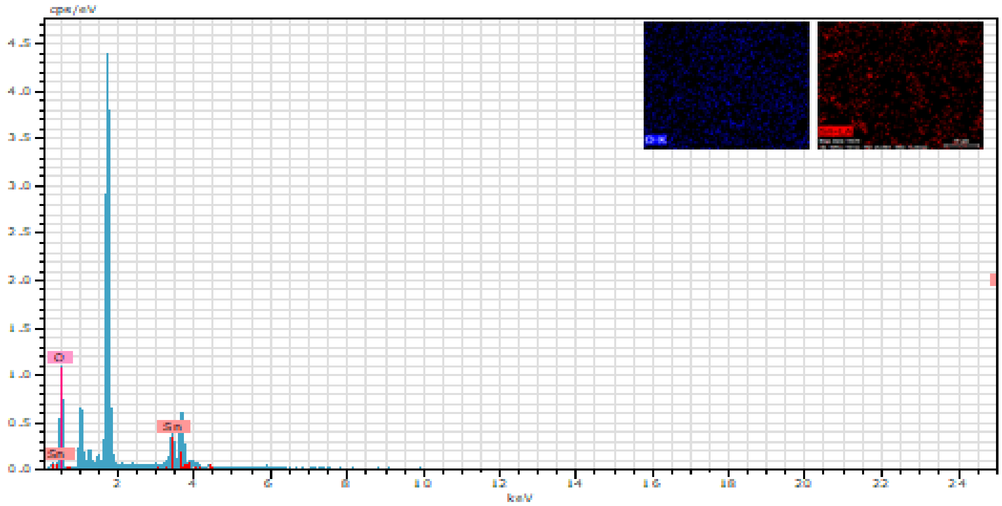


Figure 2 EDX results of pure SnO_2 NPs

Table 2 Quantitative results from EDX analysis for pure SnO2 NPs

Element	Weight %	Atom %
Sn	73.89	95.45
O	26. 11	4.55
SUM	100	100

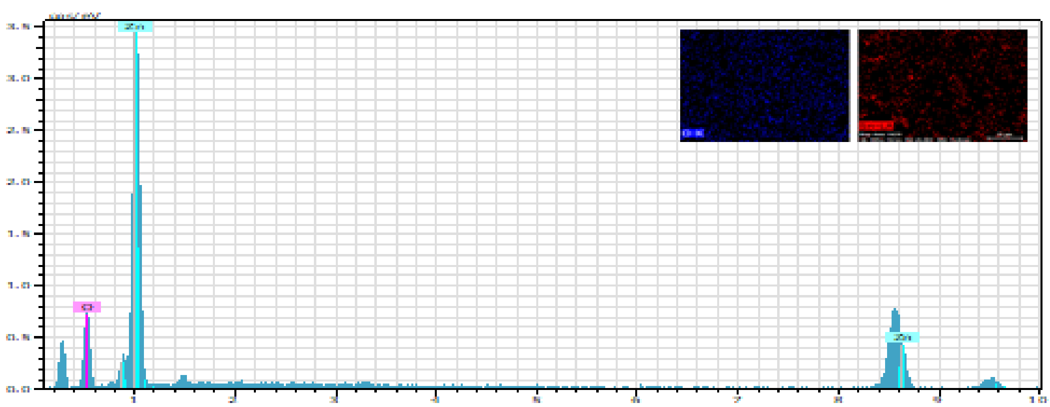


Figure 6 EDX results of pure ZnO NPs 6

Table 3 Quantitative results from EDX analysis for pure ZnO

Element	Weight %	Atom %
Sn	73.89	95.45
O	26. 11	4.55
SUM	100	100

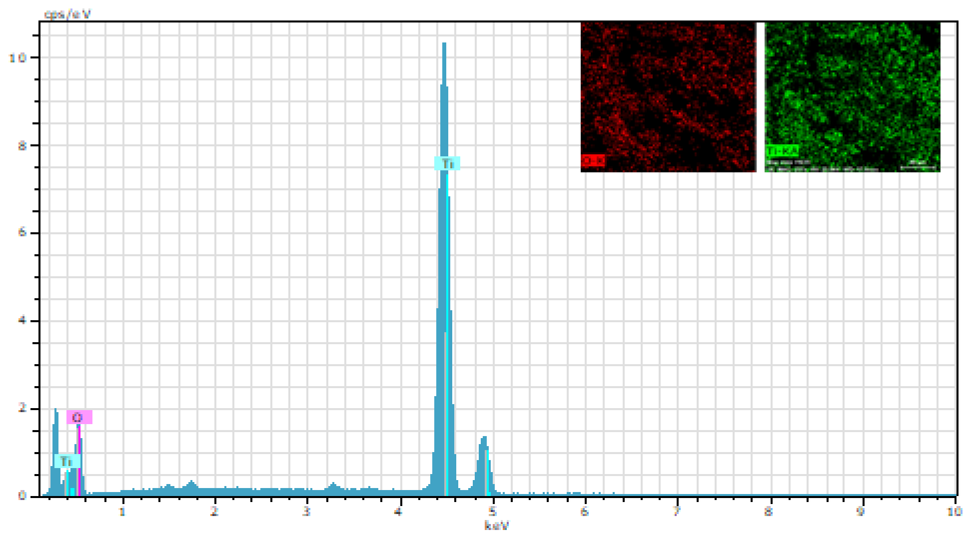


Figure 3 EDX results of pure TiO_2 NPs prepared and calcinated at 500ºC for 2 hours

Table 5 Quantitative results from EDX analysis for TiO_2 NPs

Element	Weight %	Atom %
Ti	70.32	87.64
O	29.68	12.36
SUM	100	100

Conclusion

The biosynthesis of SnO_2/ZnO/TiO_2 using potato Extracted extract as a reducing agent has been successfully demonstrated. The structural analysis revealed that the average crystallite sizes of the synthesized ZnO, TiO_2, and SnO_2 nanoparticles were 16.41 nm, 22.68 nm, and 21.75 nm, respectively. FE-SEM analysis showed that the nanoparticles had an average size of approximately 35-36 nm, and EDX analysis confirmed their elemental composition. These findings indicate that the biosynthesized nanocomposites possess desirable structural and morphological properties. The green synthesis method employed in this study provides a cost-effective and environmentally friendly approach for producing nanocomposites with potential industrial applications.

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