IRAQI JOURNAL OF APPLIED PHYSICS Vol. 20, No. 3B, August 2024, pp. 638-642

Proceedings of 5th International Specialized Conference of Education College on Physics and Applied Sciences (5thICECAS24), 22-23 April 2024

Bashaer S. Faris
Ahmed N. Abd
Basaad H. Hamza

Department of Physics,
College of Science,
Mustansiriyah
University,
Baghdad, IRAQ

Synthesis of Tin Oxide Nanoparticles by Celery Leaves Extract for Antibacterial Activity

Tin oxide nanoparticles (SnO_2 NPs) were prepared by a biological method using plant extracts as reducing agents. Celery extract serves as both a reducing agent and a protective layer for the Sn ions. The prepared tin oxide nanoparticles were crystalline. Antimicrobial and antifungal properties of these nanoparticles were demonstrated. While it had an inhibition effect of about 16 mm on Candida, E. coli, and Klebsiella sp., the corresponding effects were 18 mm and 15 mm, respectively.

Keywords: Tin oxide; Nanostructures; Biosynthesis; Antifungal effects; Celery extract
Received: 19 January 2024; Revised: 4 March 2024; Accepted: 4 April 2024

1. Introduction

Despite developments in these fields, nanotechnology is still vital to the study of materials in general, and to the establishment of their basic properties in particular, in contexts where the microscopic scale is crucial. [1]. Therefore, nanoparticles are now very important in all areas of chemistry, as well as in business and health. In nanobiotechnology, the main focus is on integrating nanotechnology into different biological systems. This field is focused with the coupling of nanotechnology and biology. The creation of nanomaterials and nanoparticles that are biocompatible, environmentally safe, and biogenic is another application of nanobiotechnology [2-4].Materials, systems, and devices at the atomic and macromolecular levels are the focus of nanoscience, while nanotechnology encompasses a wide range of techniques for manipulating structures, materials, and devices at the nanoscale in design, synthesis, characterization, and application. It is common for the dimensions to be less than 100 nanometers (<100 nm) in scale. [5].An important n-type semiconductor with a 3.6 eV band gap, SnO2 has many uses in electronics, optics, sensors, and rechargeable batteries. The synthesis of SnO2 NPs has been accomplished using various methods, such as sol-gel, hydrothermal, co-precipitation, solve thermal, and chemical vapor deposition. Nevertheless, because of their low cost, ease of handling, and environmental acceptability, nanomaterials synthesized from plant resources are preferred. Utilizing XRD, SEM, AFM, FTIR, and UV-Vis data inside the biological approach, the surface and structural characteristics of the synthesized SnO2 NPs were investigated [6].Crucial are eco-friendly technologies and nanoparticles produced in a sustainable manner [7, 8]. "Biogenic synthesis" is an emerging field of nanotechnology that has the potential to create nanoparticles in an eco-friendly and cost-effective way [9–11]. In this research, we discuss the preparation of celery extract used to reduce tin salts to prepare tin oxide nanoparticles and use them for medical applications.

2. Experimental Part

Plant extract-mediated bio reduction is the usual procedure for producing nanoparticles at temperatures below 80°C. This involves mixing an aqueous plant extract with an aqueous solution of the metal salt and deionized water. Figure (1) demonstrates that the time required to complete this technique might range from thirty minutes to an hour or more, depending on how long it takes for the plant to dissolve. Consequently, in order to produce high-quality nanomaterials (artificial methods), a straightforward and easy biosynthesis of mineral nanoparticles is necessary. Natural occurrences in biological systems are a part of the biological pathway, which follows the laws of nature. The term "green nanotechnology" has recently gained a lot of traction. Due to its strict crop management restrictions and high sanitary requirements, microbial-mediated synthesis, a biological approach for generating NPs, is not now commercially practicable [12].

In Fig. (2), we can see a solution of celery extract with SnO_2 NP_s. The process of creating SnO_2 nanoparticles using celery extract yields these results. In order to make an aqueous solution, the celery plant is ground to a consistency of 150 mL in distilled water heated to 50 to 60 degrees Celsius. Then, 2 grams of the plant are added gradually and left at the same temperature for 30 minutes. The solution turns yellow after a while. A gradual shift in color indicates the creation of tin oxide nanoparticles, represented by the symbol (B2). Once cooled in a beaker, the extract was filtered using filter paper. In a 100 mL beaker, dissolve 1.89g of SnCl2 at 60°C for one hour under standard atmospheric pressure. After being thoroughly mixed at 60°C, the extract (15 mL) was added.

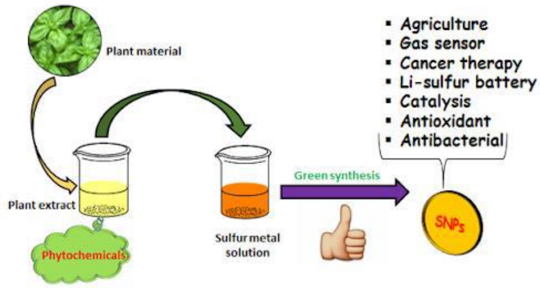

Fig. (1) Green synthesis method [13]

Fig. (2) Celery plant and (SnO_2) NP_s solution

A variety of characterization techniques were used to describe the production of SnO_2NP_s. These included x-ray diffraction (XRD), field-emission scanning electron microscopy (FE-SEM), atomic force microscopy (AFM), Fourier-transform infrared (FTIR) spectroscopy, and UV-visible spectroscopy. Determining the degree of a drug's influence on the environment and human health may require the detection or diagnosis of the substance.

3. Results and discussion

One helpful method for studying crystalline materials is X-ray diffraction. Sample orientation, lattice parameters, composition, and crystalline phase can all be ascertained using this method. Figure (3) displays the X-ray diffraction pattern (XRD) of a biosynthetic tin oxide nanostructured film that was cast on a glass substrate using a three-drop drop casting procedure [14]. The reflections of (110), (101), (211), and (301) are identical to the patterns of SnO_2 reference (JCPDS card 00-046-1088), as is readily apparent. The size of the biosynthesized SnO_2 nanocrystals was also determined using the Debye-Scherrer formula [15-17], as shown in table (1).

$$D = \frac{0.9\lambda}{\beta\ cos\theta} \quad (1)$$

where D or C.S., λ, β or FWHM and θ are crystalline size, wavelength for x-ray which is equal to 1.5406Å, the full-width at half maximum, and a degree of the diffraction or the Bragg angle, respectively

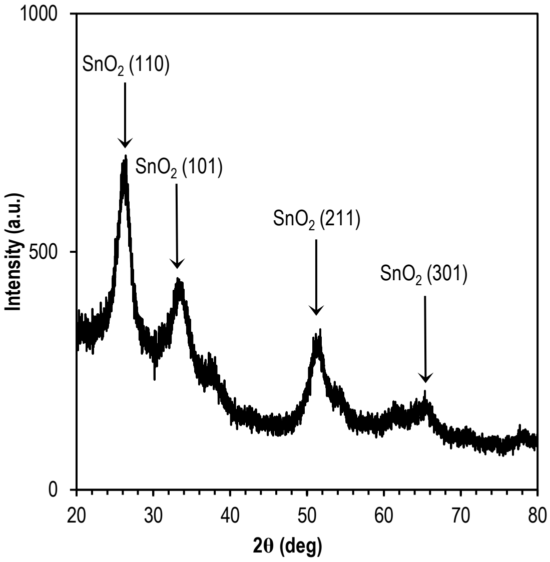

Fig. (3) XRD pattern of SnO_2 nanostructure, which precipitated on a glass

Table (1) Structural parameters of B2 nanostructure

Method	2θ (deg)	FWHM (deg)	D (nm)	η X 10²	σ (LINE/m²)
Biological	25.9	1.828	4.442	7.799	50.665
	32.8	2.303	3.583	9.670	77.885
	51.03	3.514	2.497	13.8750	160.347
	65.3	4.401	2.138	16.203	218.685

The heat treatment technique causes micro-strains and structural dislocations in the film. Equation (2) calculates the dislocation density [18]:

$$\sigma = \frac{1}{D^2} \quad (2)$$

Where **δ** is the dislocations density, where the micro-strain of the film was estimated using the equation [18]:

$$\eta = \frac{\beta\cos\theta}{4} \quad (3)$$

Tin oxide nanoparticles made using the green synthesis method were studied for size, shape, and morphology with the use of field-emission scanning electron microscopy (FE-SEM), which examines material's morphology at extremely high magnifications [19]. An examination was carried out using FE-SEM at 1.00kx and 120.00kx magnifications, with a resolution varying from 10μm to 500nm, as shown in Fig. (4). Tin oxide nanoparticles were produced using an environmentally friendly process, and their size, shape, and morphology were examined using FE-SEM technology. Drop casting was employed to biosynthesize and fabricate the B2 thin film on a glass substrate. A value of about 72.20 nanometers was produced by the nanostructure.

Figure (5) displays the results of the surface topographic analysis, a method for identifying and mapping the topography of surfaces with micro and nano dimensions, conducted on films generated using the biosynthetic process and applied onto glass substrates at a temperature of 80°C. Such surfaces were photographed and studied using a high-powered atomic force microscope (AFM) [20]. The outcomes are shown in Fig. (5).

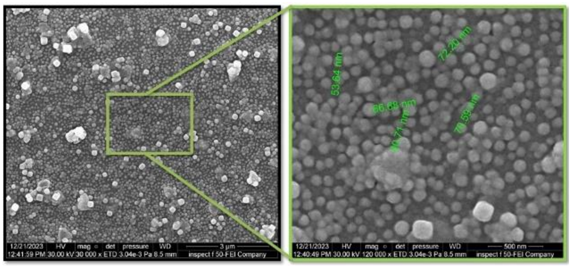

Fig. (4) FE-SEM images of green synthesized SnO_2 NPs deposited on a glass (scale bar = 3μm, 500nm)

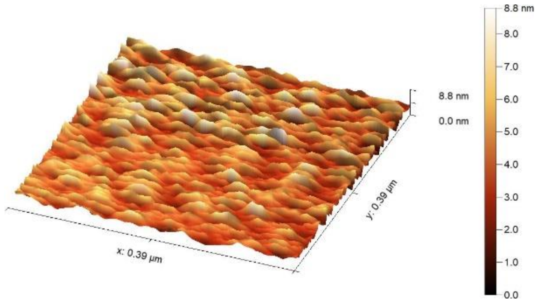

Fig. (5) 3D AFM image for SnO_2 NPs

One intriguing tool utilized in nanotechnology for gauging the pliability of micro and nanoparticles is the atomic force microscope. Scanning microscope probes (SPMs) include instruments like atomic force microscopes. Surface areas of insulators and conductors are the usual targets for its measurement capabilities. It also gives us precise data on the quantity and size of grains, the surface roughness, and the rate of surface roughness (RMS).

The functional groups discovered in the material being examined are depicted in Fig. (6) [21]. Using FTIR spectroscopy to look into the many vibration modes that the chemical bonds involved in SnO_2 NP_s biosynthesis could exhibit [22]. The functional groups were recorded within the range between 400-4000 cm^{-1}, and figure (6) clearly shows this. FTIR spectra of B2 NPs can be seen in it, and it shows strong peaks at 547, 1074, 1111, 2359, 2600, 2853 and 3371 cm^{-1}. Alcohols, phenols with hydroxyl O–H may be identified by the peak located at 3371cm^{-1}. CH and CH_2 stretching aliphatic group are responsible for the peak at 2853cm^{-1}, the alkynes groups' C≡C and C-O-C polysaccharide modes are responsible for the peak at 1111cm^{-1}, and C-O carbohydrate modes are responsible for the peak at 1074cm^{-1}. Finally, for CH out of plane aromatic band which is located at the peak 547cm^{-1}. Biosynthesis-produced nanoparticles have UV-visible absorption spectrum, which is explained in Fig. (7).

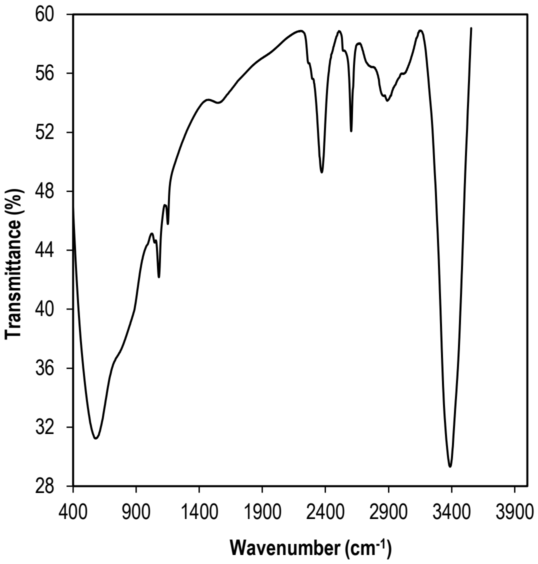

Fig. (6) FTIR spectrum for the transmittance of (SnO_2) NP_s synthesized method

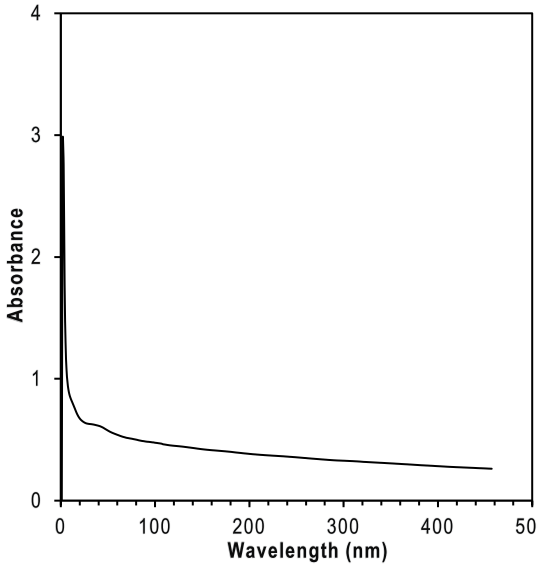

Fig. (7) UV-visible absorption spectrum of SnO_2 NP_s colloid

While most of the 10 million annual fatalities and numerous chronic illnesses caused by microbiological infections occur in tropical nations, the developed world is not immune either. Antibiotics have been utilized to treat bacterial illnesses due to their efficacy and affordability. While antibiotics have undoubtedly helped biobiotics, their abuse has led to bacterial resistance mechanisms and the subsequent rise of multidrug-resistant microbes [23]. The rise of drug-resistant bacteria has left doctors with little choice but to resort to extreme measures to treat their patients. Because antibiotics encourage the emergence and evolution of strains with varied genetic and phenotypic features, their promise as therapeutic agents is diminished by their overuse. Bacteria can cover themselves with a biofilm and start multiplying. They become immune to antibiotics when they clump together and encase themselves in an extracellular matrix they create [24]. Antidrug resistance ranks high among the most pressing global public health concerns. Consequently, there has to be a change in approach to treating microbial diseases. Biological imaging, medication delivery, and antibacterial activity are just a few of the biological applications of nanoparticles due to their unique physical and chemical properties, which include a large surface area, optical qualities, antimicrobial activity, catalytic activity, electrical characteristics, and magnetic properties [25]. Even now, people are talking about it [26]. Nanoparticles' effects on bacteria and fungi are a matter of debate. Nanoparticles have the ability to bind to the cell wall of bacteria or fungi, which they can then penetrate to change the structure of the cell membrane, making it more permeable. This process leads to the death of the bacteria. Metal oxide nanoparticles have recently been recognized as an effective antimicrobial agent with the ability to target several locations within and outside of cells. One mechanism by which nanoparticles exert their antibacterial effects is through the ions they emit. Their high surface area to volume ratio and diminutive size allow them to bind tightly to tiny membranes, which enhances their activity even further. Based on the composition and structure of their cell walls, bacteria can be classified as either Gram-positive (+) or Gram-negative (-). When it comes to the impact of nanoparticles on bacteria, the makeup and chemistry of the cell walls of Gram-positive and Gram-negative bacteria are significantly different. Candida, a type of fungus that can cause skin infections, is one of the many types of fungi shown in Fig. (8), which also includes other types of fungi worldwide [27].

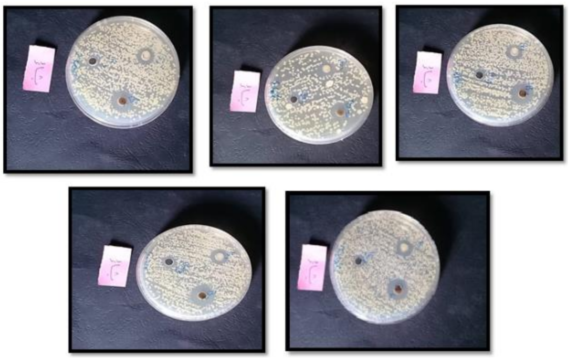

Fig. (8) Antibacterial activity of SnO_2 NPs

4. Conclusion

There are several ways to prepare tin oxide nanoparticles, but one of the most effective is the green synthesis method. This approach uses salts and plants instead of water, and it generates vast quantities of tin oxide nanoparticles of highly inexpensive quality. Additionally, it poses less of a threat than any of the alternatives. Thus, our research has laid down a quick method for creating SnO2 nano-structures utilizing celery extract in a biological approach to SnO2 manufacture or green synthesis. All of the outcomes were nanoscale, which proves that green synthesis is a viable method for making nanoparticles. Because it is a sustainable, nontoxic, environmentally friendly, and cost-effective process, green NPs production has garnered a lot of attention. Using various plant materials, microorganisms, and naturally existing proteins, several studies have shown that SnO_2 NPs can be synthesized in an ecologically friendly manner. Regardless of their origin, the literature review reveals that green substrates act as reducing agents, stabilizing agents, and caps.Because plant-mediated synthesis is less expensive, easier to handle, and less hazardous than utilizing microbes, it is one of the more environmentally acceptable methods of synthesizing SnO_2.

References

[1] E.A. Latief, A.T. Mohi and A.N. Abd, “Effect of Natural Dye on the Spectral Response of the Heterojunction Ag/ZnO/Ps/Si/Ag for Photodetector Application”, *Int. J. Nanosci.*, 22(6) (2023) 2350048.

[2] D. Ananda et al. “Synthesis of gold and silver nanoparticles from fermented and non fermented betel leaf”, *Int. J. Nanomater. Biostruct.*, 5 (2017) 20-23.

[3] Y. Wang and N. Herron, “Nanometer-sized semiconductor clusters: materials synthesis, quantum size effects, and photophysical properties”, *J. Phys. Chem. A*, 95 (1991) 525-532.

[4] M.A. Faraj, M.A. Jabbar and A.N. Abd, “Bismuth oxide aqueous colloidal NPS obtained by a green synthesis inhibit candida albicans”, *AIP Conf. Proc.*, 2834 (2023) 090009.

[5] H. Singh et al., “Ecofriendly synthesis of silver and gold nanoparticles by Euphrasia officinalis leaf extract and its biomedical applications”, *Artif. Cells, Nanomed. Biotech.*, 46(6) (2018) 1163-1170.

[6] S. Haq et al., “Green synthesis and characterization of tin dioxide nanoparticles for photocatalytic and antimicrobial studies”, *Incl. Pub. Trust. Sci. Exp.*, 7 (2020) 025012.

[7] B.J. Alwan, A.N. Abd and N.H. Zaki, “Inhibitory effect of lithium oxide nanoparticle produced by green synthesis method”, *AIP Conf. Proc.*, 2834 (2023) 090012.

[8] K. Fleischer, E. Arca and I.V. Shvets, *Sol. Ener. Mater. Sol. Cells*, 101 (2012) 262-269.

[9] N.F. Habubi et al., “Improving the Photoresponse of Porous Silicon for Solar Cell Applications by Embedding of CdTe Nanoparticles”, *Indian J. Pure Appl. Phys.*, 53 (2015) 718.

[10] M.K. Al Turkestani and K. Durose, *Sol. Ener. Mater. Sol. Cells*, 95 (2011) 491-496.

[11] S. Girish Kumar and K.S.R. Koteswara Rao, *Ener. Enviro. Sci.*, 7 (2014) 45-102.

[12] S. Iravani, “Green synthesis of metal nanoparticles using plants”, *Green Chem.*, 13 (2011) 2638-2650.

[13] B.J. Alwan, A.N. Abd and N.H. Zaki, “Inhibitory effect of lithium oxide nanoparticle produced by green synthesis method”, *AIP Conf. Proc.*, 2834 (2023) 090012 (2023).

[14] A.N. Abd, “Improved photoresponse of porous silicon photodetectors by embedding CdS nanoparticles”, *World Sci. News*, 19 (2015) 32.

[15] K. Murali, P. Elango and K. Andavan, “Preparation of Ag nanoparticles films and their characteristics”, *J. Mater. Sci.: Mater. Electron.*, 19(3) (2008) 289-293.

[16] S. Kotthaus, B. Hang and H. Schafer, “Study of isotropically conductive bondings filled with aggregates of nano-sited Ag-particles”, *IEEE Trans. Compon. Packag. Technol.*, 20 (1997) 15-20.

[17] Y.N. Al-Jammal “Solid State Physics”, Mosul University, Arabic version (1990).

[18] W. Zhang, “Research and development for antibacterial materials of silver nanoparticle”, *New Chem. Mater.*, 31 (2003) 42-44.

[19] S.J.B. Reed, **“Electron microprobe analysis and scanning electron microscopy in geology”**, Cambridge University Press (2005).

[20] K.M. Lang et al., “Conducting atomic force microscopy for nanoscale tunnel barrier characterization”, *Rev. Sci. Instrum.*, 75(8) (2004) 2726-2731.

[21] M.A. Mijares, UV-Visible Photodetector with Silicon Nanoparticles (2012).

[22] M.M. Silván, “HAP/TiO_2 and HAP/TiN Structures Surface Modifications for Enhanced Biocomptatibility”, PhD thesis, Universidad Autónoma de Madrid (2001).

[23] I.E. Mba and E.I. Nweze, “Nanoparticles as therapeutic options for treating multidrug-resistant bacteria: Research progress, challenges, and prospects”, *World J. Microbiol. Biotech.*, 37 (2021) 1-30.

[24] F. Amaro et al., “Metallic nanoparticles—friends or foes in the battle against antibiotic-resistant bacteria?”, *Microorgan.*, 9(2) (2021) 364.

[25] T. Iqbal et al., “Plant-mediated green synthesis of zinc oxide nanoparticles for novel application to enhance the shelf life of tomatoes”, *Appl. Nanosci.*, (2022) 1-13.

[26] S. Chauhan, D.N. Kumar and L.S. Upadhyay, “Facile synthesis of iron oxide nanoparticles using Lawsonia inermis extract and its application in decolorization of dye”, *BioNanoScience*, 9 (2019) 789-798.

[27] A. Yoo, “Effect of zinc oxide and silver nanoparticles on intestinal bacteria”, PhD thesis, University of Missouri, Columbia (2013).