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Investigation of *Solanum lycopersicum* Capped Zinc Oxide Nanoparticles for Cancer Application

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ABSTRACT

The present work deals with the synthesis and characterization of ZnO nanoparticles using *Solanum lycopersicum* extract. The synthesized nanoparticles were characterized by various techniques such as XRD, FTIR, SEM and EDAX. The X-ray diffraction pattern analysis has revealed the presence of crystalline nature in Zinc oxide nanoparticles. The functional groups were analyzed using Fourier Transform Infrared Spectroscopy. The morphological structure of the sample was analyzed using Scanning Electron Microscopy. The purity and elemental composition of the sample were identified by Energy Dispersion X-ray Diffraction analysis.

Keywords: Microwave method; *Solanum lycopersicum* extract; Sodium hydroxide; Zinc nitrate; Zinc oxide.

1. INTRODUCTION

Nanotechnology is the study and application of very small things and can be used across all the other science fields, such as chemistry, biology, environmental science, physics, materials science and engineering (Surya *et al.* 2020). A nanoparticle is a microscopic particle with at least one dimension less than 100 nm. Nanoparticle research is currently an area of intense scientific research due to a wide variety of potential applications in biomedical, optical and electronic fields. Undetectable by the human eye, nanoparticles can exhibit significantly different physical and chemical properties to their larger material counterparts (Surya *et al.* 2020).

Tomato (*Solanum lycopersicum*) is a botanical fruit (Fig. 1). It is shiny and smooth. It has many small seeds. It is also very good for health. There are many different types of tomatoes available. Including tomatoes in the diet can help protect against cancer, maintain healthy blood pressure and reduce blood glucose in people with diabetes.

Tomatoes contain key carotenoids such as lutein and lycopene. These can protect the eye against light-induced damage. They are added to wraps or sandwiches, sauces and salsas. Alternatively, they can be cooked or stewed, as these preparation methods can boost the availability of key nutrients. Tomatoes are in the top-ten fruits and vegetables for containing levels of pesticide residue. Tomatoes are an excellent source of vitamin C and other antioxidants. With these components, tomatoes can help combat the formation of free radicals. Free radicals are known to cause cancer (Monawara *et al.* 2020).

A recent study in the journal *Molecular Cancer Research* linked the intake of high levels of beta-carotene to the prevention of tumor development in prostate cancer. Tomatoes also contain lycopene. Lycopene is a polyphenol - a plant compound, linked with one type of prostate cancer prevention.

Fig. 1: *Solanum lycopersicum*.

A study of the Japanese population demonstrates that beta-carotene consumption may reduce the risk of colon cancer. Fiber intake from fruits and vegetables is associated with a lowered risk of colorectal cancer. Diets rich in beta-carotene may play a protective role against prostate cancer. Further human-based research is needed to explore the possible roles of lycopene and beta-carotene in preventing or treating cancer (Sharmila *et al.* 2019). Zinc oxide is an inorganic compound with the formula ZnO. It is a white powder that is insoluble in water. ZnO is present in the earth's crust as the mineral zincite. Zinc oxide is commonly found in medical ointments where it used to treat skin irritations. In more recent times, zinc oxide finds its applications in semiconductors, concrete, ceramics and glass and even cigarette filters.

Zinc oxide also has antibacterial and deodorizing properties. For this reason, it is employed in medical applications such as baby powder and creams to treat conditions such as diaper rash, other skin irritations and even dandruff. Due to its reflective properties, it is also used in sun blocks and can often be seen on the nose and lips of lifeguards at the beach.

2. MATERIALS & METHODS

2.1 Materials Required

The entire chemicals such as Zinc nitrate, distilled water and other sodium hydroxide ingredients utilized in this work were purchased from Erode, Tamilnadu. The tomato (*Solanum lycopersicum*) was collected from in and around Erode, Tamilnadu, India.

2.2 Preparation of Tomato Extract

Take 50 g of tomato (*Solanum lycopersicum*) was washed with double distilled water. The skin was removed from the tomato and the whole mass was squeezed to get the juice. This juice was dissolved in 100 ml of distilled water and filtered using a Whatman filter paper. Then it was stored at room temperature for further use.

2.3 Preparation of Zinc Oxide Nanoparticle

Zinc nitrate was used as a precursor for the synthesis of ZnO nanoparticles. 10 g of zinc nitrate was dissolved in 50 ml of distilled water and stirred for 30 minutes. The mixture was boiled at 80 °C for 5 min. Then NaOH solution was added drop-wise to maintain pH as 12. This mixture was continuously stirred for half an hour and the synthesized zinc oxide sample was subjected to ageing for 24 hours. The settled precipitate was washed with double distilled water and the final product was kept in a microwave oven at 350 W for 30 minutes. The dried sample was grained using a mortar to get a fine nanopowder of tomato-capped zinc oxide.

3. CHARACTERIZATION TECHNIQUES

3.1 XRD Analysis

The prepared samples were analyzed using X-ray Diffraction (XRD) technique. This XRD pattern predicts the lattice parameters (a and c), unit cell volume and crystalline size of the sample. The lattice parameter of the sample was calculated using the equation:

$$1/d^2 = 4(h^2+hk+k^2)/3a^2) + (1^2/c^2)$$

where, d is the spacing between the planes and a and c are the lattice parameters. The unit cell volume (V) of the sample was found using the equation:

$$V = (\sqrt{3}/2) + a^2 + c^2$$

The average crystalline size of the sample was determined using Scherrer's formula.

$$D = K\lambda /\beta\cos\theta$$

where, D denotes the average crystalline size of the sample, K represents the broadening constant, λ denotes the wavelength of CuKα radiation source (1.54 Å), β represents the full width at half-maximum and θ denotes the angle of diffraction.

3.2 Fourier Transform Infrared Spectroscopy (FTIR)

Fourier Transform Infrared Spectroscopy relies on the fact that most molecules absorb light in the infra-red region of the electromagnetic spectrum. This absorption corresponds specifically to the bonds present in the molecule. The frequency range is measured as wave numbers typically over the range 4000 – 600 cm-1. It is a technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid, or gas. This simultaneously collects high-spectral-resolution data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer, which measures intensity over a narrow range of wavelengths at a time (Vijayakumar *et al.* 2020).

3.3 Energy Dispersive X-Ray Spectroscopy (EDAX)

The Energy Dispersive X-ray (EDAX) microanalysis is a technique of elemental analysis associated with electron microscopy based on the generation of characteristic X-rays that reveals the presence of elements in the specimens. The EDAX microanalysis is used in different biomedical fields by many researchers and clinicians. The spectrum of EDAX microanalysis contains both semi-qualitative and semi-quantitative information. EDAX technique is being used in the study of drugs, such as drug delivery. EDAX is a vital tool to detect nanoparticles (Yasotha *et al.* 2020).

4. RESULTS

4.1 XRD Analysis

The XRD pattern of ZnO nanoparticles has been shown in Fig. 2. The XRD pattern confirmed the crystalline structure with all possible peaks. The peaks in XRD pattern were observed at 2θ values, which correspond to the lattice planes 101, 102 and 103, according to the database. From XRD results (Table 1) the crystalline size of the prepared sample was identified.

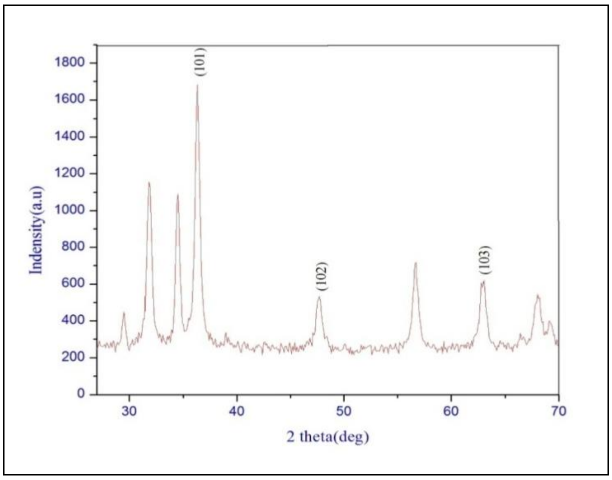

Fig. 2: XRD spectrum of ZnO nanoparticles.

4.2 FTIR Analysis

Infrared spectroscopy gives information on molecular vibration, or more precisely on the transition between vibration and absorption energy levels. Absorption of radiation results in the excitation of bond deformation. Either stretching or bending vibration occurs at certain quantized frequencies (Fig. 3).

The FTIR spectra predicted the characteristic bands present in the sample. The observed peaks resulted from the ZnO microwave method were at 3866.77 and 869.80 cm^{-1}. The broad peak was observed at 3866.77 cm^{-1} (Alcohol), which represents O-H stretching band.

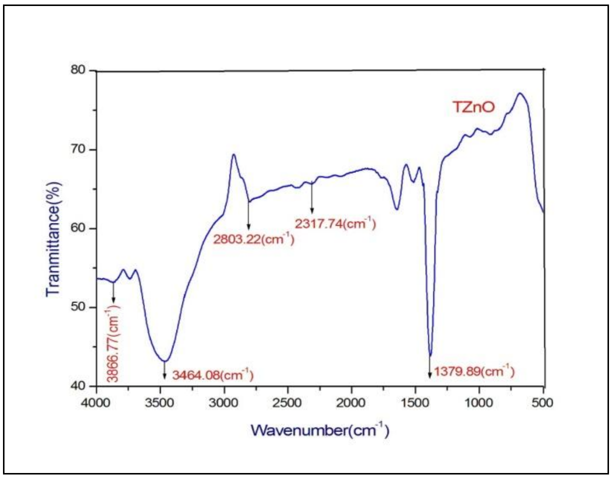

Fig. 3: FTIR spectrum of ZnO nanoparticles.

The absorption in the region 3464.08 cm^{-1} was due to the associative N-H stretching. C-H stretching was confirmed by the absorption peak of 2803.22 cm^{-1} (Alkynes). The region at 2317.74 cm^{-1} represents OH stretching and 1379.89 cm^{-1} (Nitro) represents N=O stretching. Then FTIR spectrum reveals the peak at 3449.87 cm^{-1} (Capped ZnO) with the stretching vibrations of N-H (Amine) bond. The present groups of Capped ZnO (Tomato-capped Zinc Oxide) were analyzed and given in Table 2.

Table 1. XRD analysis of ZnO nanoparticles.

Sample	2θ (deg)	FWHM (deg)	D (Å)	Intensity (count)	Crystalline Size (nm)	Average Crystalline Size (nm)	hkl	Lattice constant		Lattice Cell Volume (Å^3)
								a=b	c	
	36.2895	0.55290	2.4735	892	15.12245		101			47.48
TZnO	47.6203	0.64580	1.9080	199	13.44745	14.53997	102	3.23	5.22	46.66
	62.8906	0.61880	1.4765	260	15.05002		103			47.71

Table 2. FTIR region of ZnO nanoparticle.

S. No.	Sample	Wave Number (cm^{-1})				
		O-H Stretching vibration (banded)	N-H Stretching vibration	C-H Stretching vibration	O-H Stretching vibration (free)	N=O Stretching vibration
1	TZnO	3866.77	34.64.08	2803.22	2317.74	1379.89

4.3 Energy Dispersive X-Ray Spectroscopy Analysis (EDAX)

EDX analysis is used to indicate the elemental composition present in the sample. Zinc and oxide peaks were observed, indicating the presence of ZnO nanoparticles. The x-axis indicates the ionization energy, and the y-axis shows the number of counts. The EDX analysis of ZnO nanoparticles was presented in Table 3; 38.07% of zinc and 61.93% of oxides confirmed the elemental composition of zinc oxide nanoparticles. Fig. 4 shows the peaks which were identified as zinc and oxide.

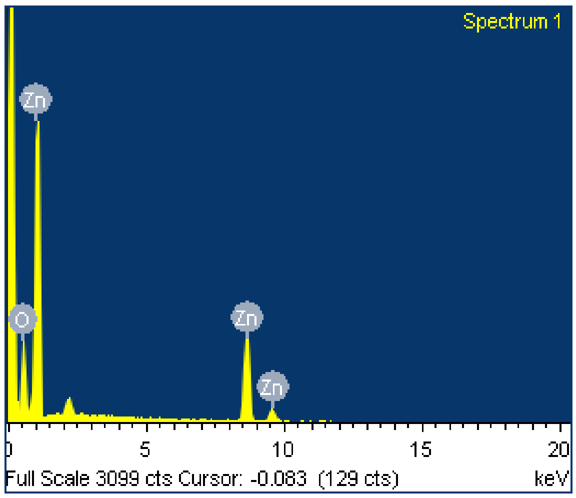

Fig. 4: EDAX spectrum of ZnO nanoparticles.

Table 3. EDAX analysis of zinc oxide nanoparticles.

Elements	Intensity	Weight	Atomic Weight
O	1.1430	28.48	61.93
Zn	0.9204	71.52	38.07
	Total		100

4.4 Scanning Electron Microscope (SEM)

SEM was used to determine the size and structure of the sample. SEM studies have revealed the size and shape of zinc oxide nanoparticles and shown the typical bright field micrograph of the synthesized zinc oxide nanoparticles. Fig. 5 shows the SEM morphology of ZnO nanoparticles prepared by green synthesis method.

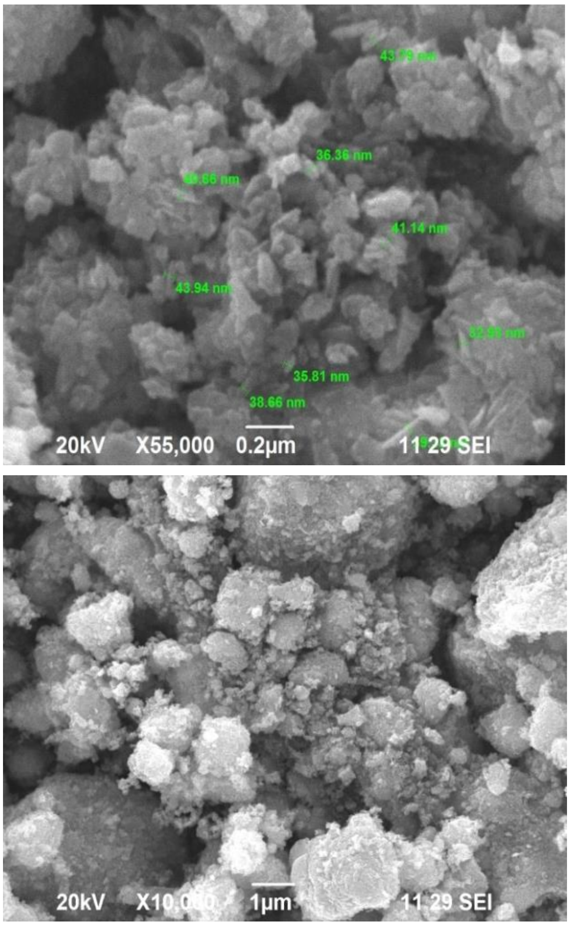

Fig. 5: SEM image of ZnO nanoparticles.

5. CONCLUSION

The present work deals with the synthesis of ZnO Nanoparticles with and without capping agent *Solanum lycopersicum* extract, by microwave irradiation method and the subsequent characterization. XRD pattern indicated the crystalline size of the sample as 4.5 nm. SEM analysis revealed the cluster-shaped partial morphology of the surface. FTIR spectrum confirmed the function groups of the sample. Finally, EDAX analysis predicted the presence of chemical components in the sample. From the results, it was concluded that the synthesized samples can be applied in the field of medicine for cancer treatment.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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