

Synthesis and Investigation of Structural, Mechanical and Optical Properties of Porous ZnO Nano Particles Prepared Via Eco-friendly Technique

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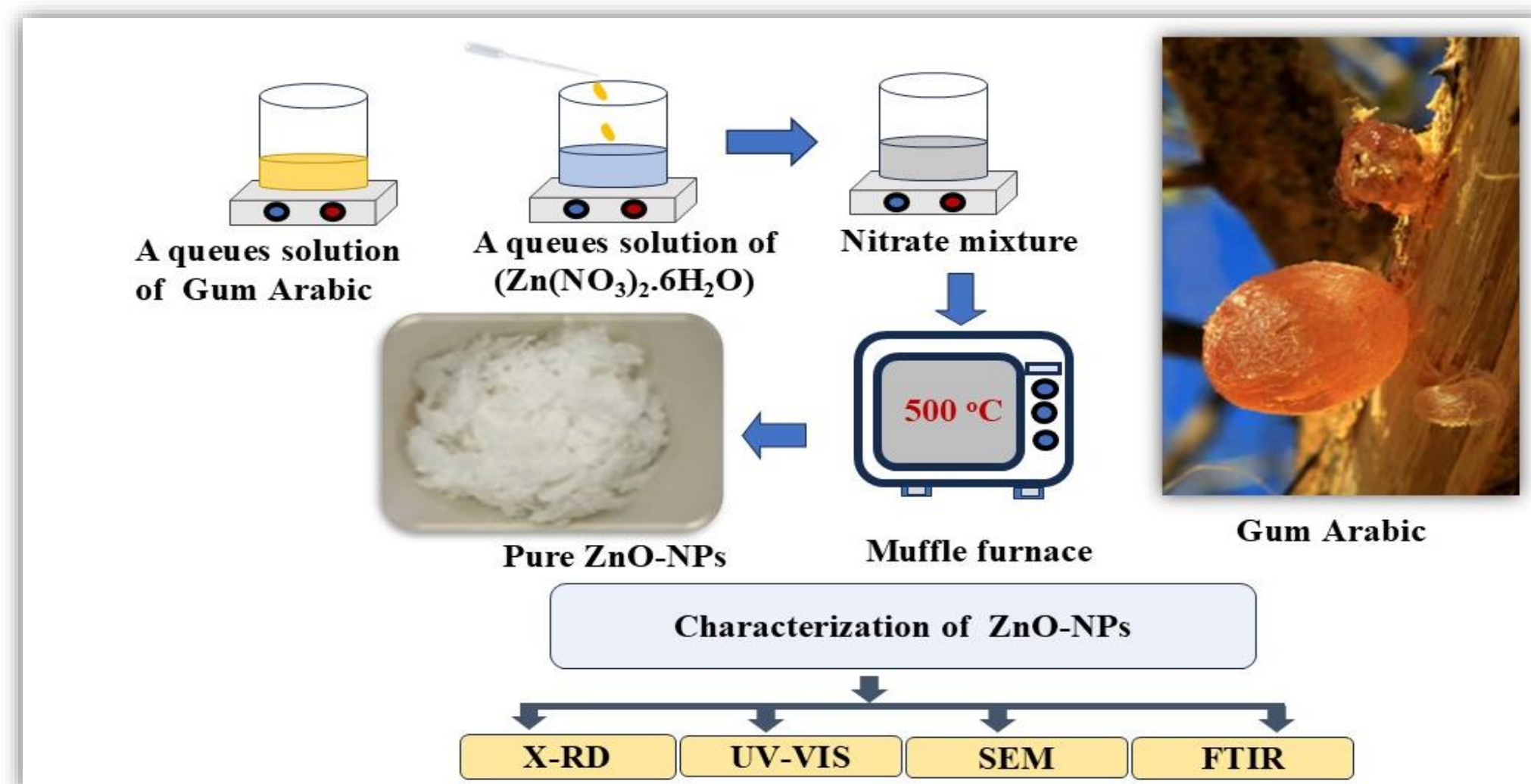
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INTRODUCTION & AIM

Zinc oxide (ZnO) categorized as an n-type II-VI semiconductor material, known for its wide band gap of 3.2 eV. The prevalent phase of ZnO is the wurtzite hexagonal phase, which remains stable under normal ambient conditions. ZnO-NPs are particularly appealing due to its remarkable optical and electrical properties, especially in relation to piezoelectric semiconducting behaviour. In addition, potential use in bio and biosensing applications.

In this work, (ZnO-NPs) were synthesized using a green eco friendly solution combustion route, employing zinc nitrate hexahydrate as the oxidizer and gum Arabic as a bio-organic fuel. No other chemical reagents were added during the synthesis process. The synthesized ZnO-NPs were characterized for average crystallite size, morphology, porosity, some of optical properties and selected mechanical parameters. Structural parameters were calculated using Scherrer's formula, while additional microstructural properties—such as internal strain, stress, and energy density—were assessed via Williamson–Hall (W–H) analysis, Size–Strain Plot (SSP), and the Halder–Wagner (H–W) approach.

METHOD



RESULTS & DISCUSSION

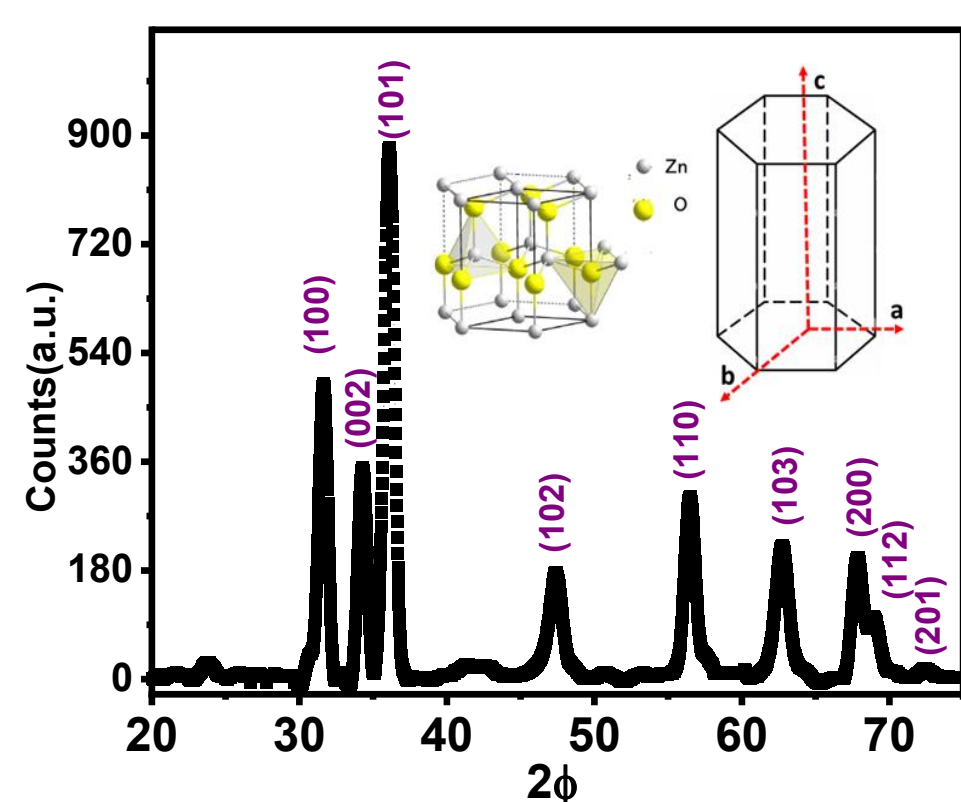


Figure 1. X-rays diffraction spectra for ZnO-NPs

Table 1. Geometrical parameter for ZnO-NPs.							
Sample	(hkl)	(2θ) (degree)	d _{hkl} (Å)	a (nm)	c (nm)	V _{uc} *10 ⁻³ (nm ³)	D _{av} (nm)
ZnO	(001)	31.615	0.283	0.327	0.523	48.335	13.58
	(200)	34.281	0.261				
	(101)	36.088	0.223				
	(201)	47.361	0.136				
Our Previous work				0.325	0.521	47.599	27.70

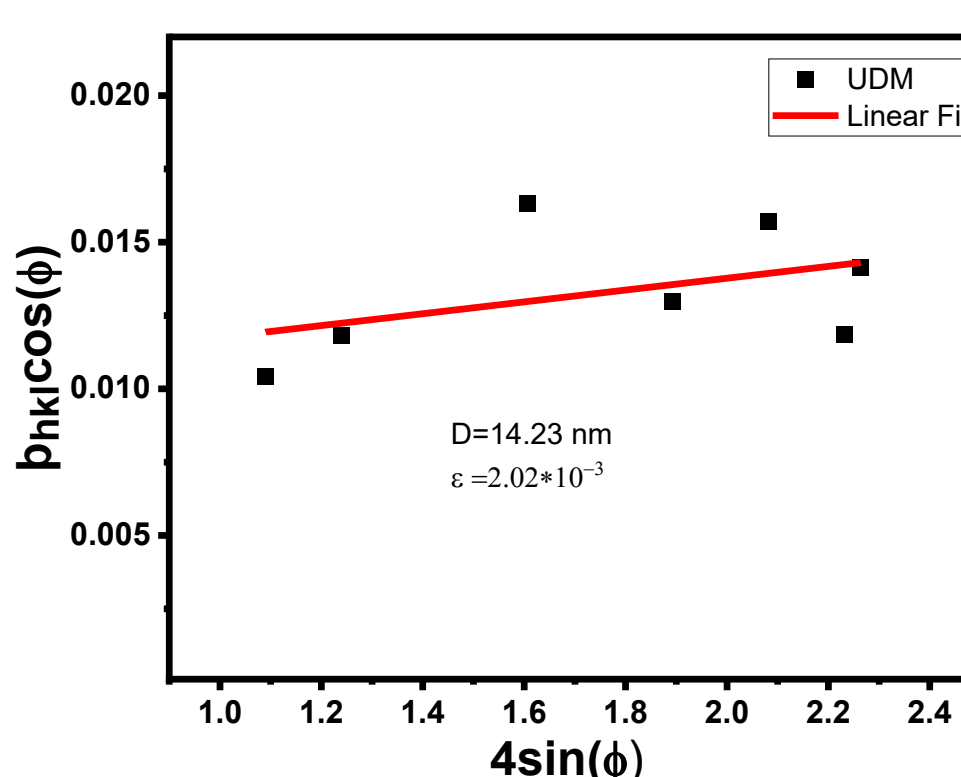


Figure 2. UDM plot for ZnO-NPs

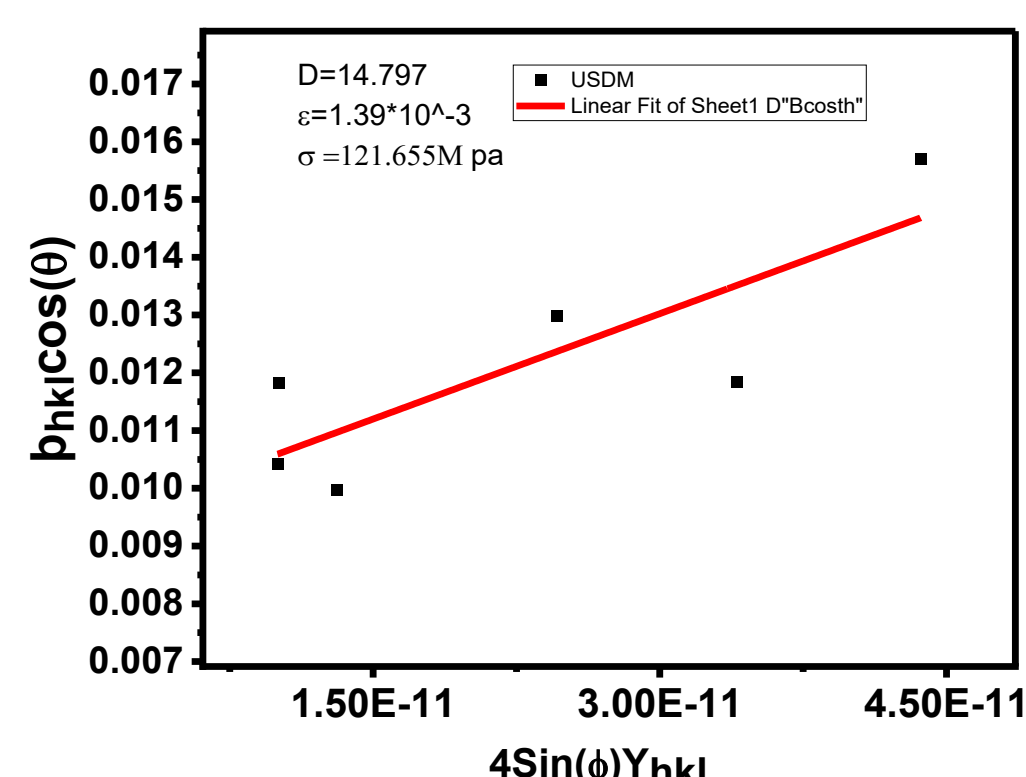


Figure 3. USDM plot for ZnO-NPs

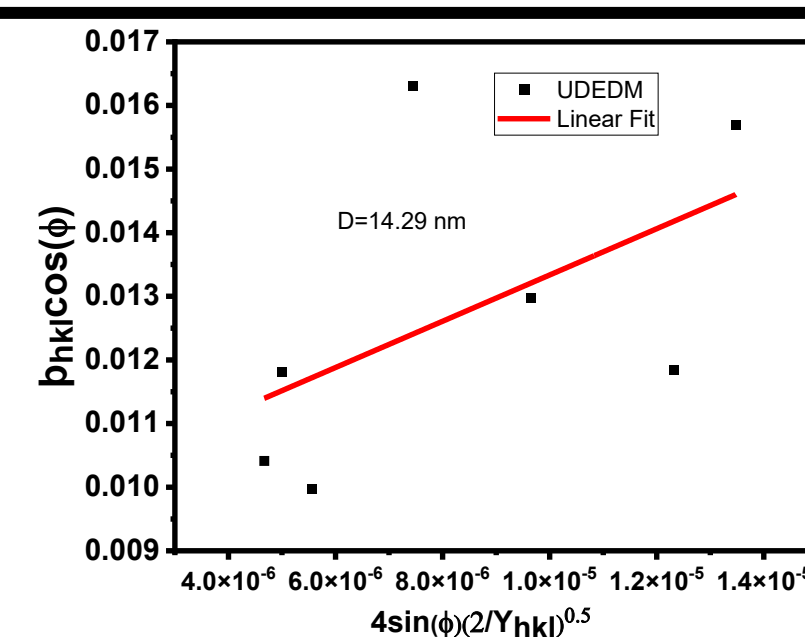


Figure 4. The UEDM plot for ZnO-NPs

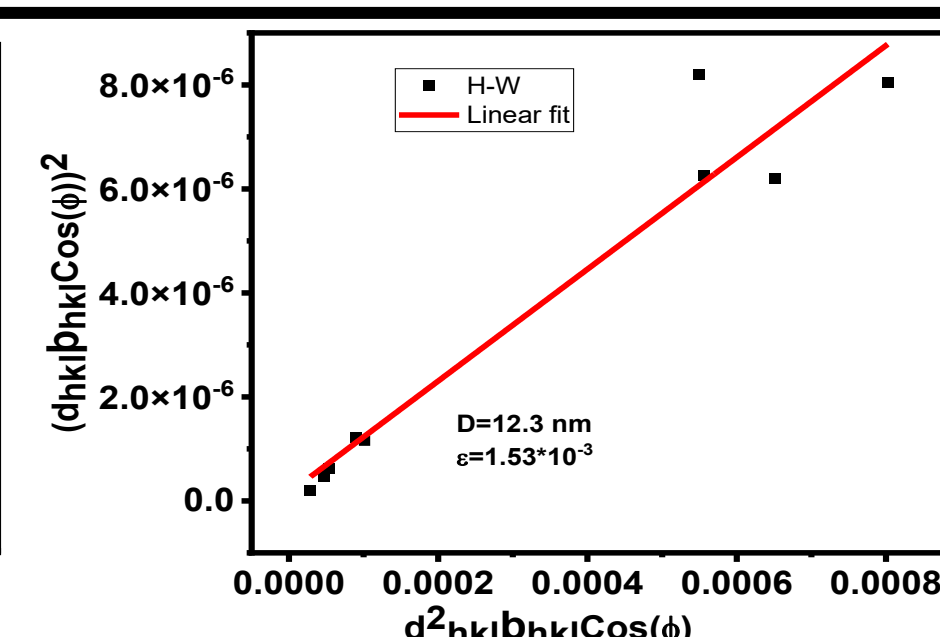


Figure 5. H-W plot for ZnO-NPs

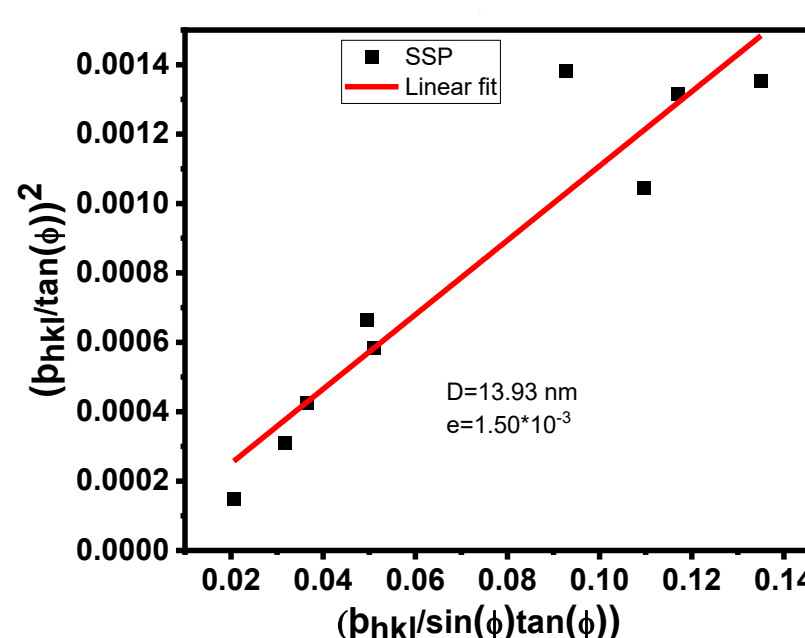


Figure 6. SSP plot for ZnO-NPs

Table 2. Estimation of microstructural parameters of ZnO-NP using W-H approximation, H-W approximation and S-S-P-approximation.			
Williamson-Hall model	UDM	D _{av} (nm)	14.23
		ε*10 ⁻³ (no unit)	2.02
		X _{av} (nm)	14.80
	USDM	ε*10 ⁻³ (no unit)	1.39
		σ (Mpa)	121.66
		D _{av} (nm)	14.29
H-W model	UEDM	U (kJm ⁻¹)	132.27
		σ (Mpa)	152.23
		ε*10 ⁻³ (no unit)	1.744
SSP model		D _{av} (nm)	12.31
		ε*10 ⁻³ (no unit)	1.53
		D _{av} (nm)	13.93
		ε*10 ⁻³ (no unit)	1.50

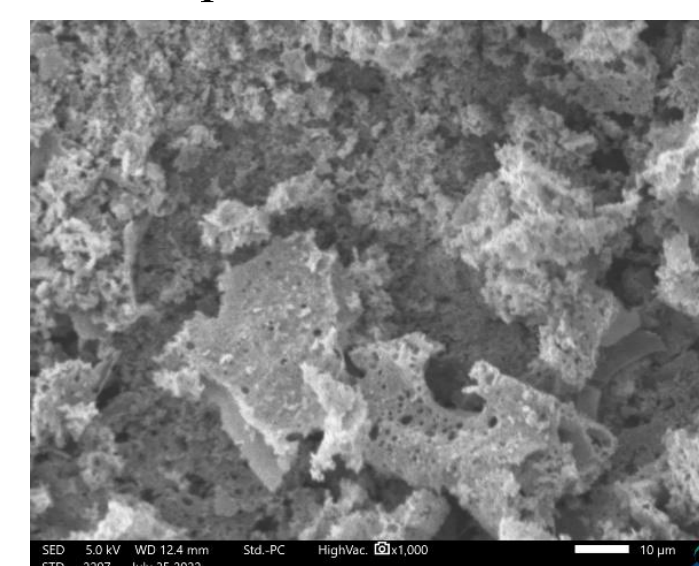


Figure 7. SEM image of ZnO-NPs

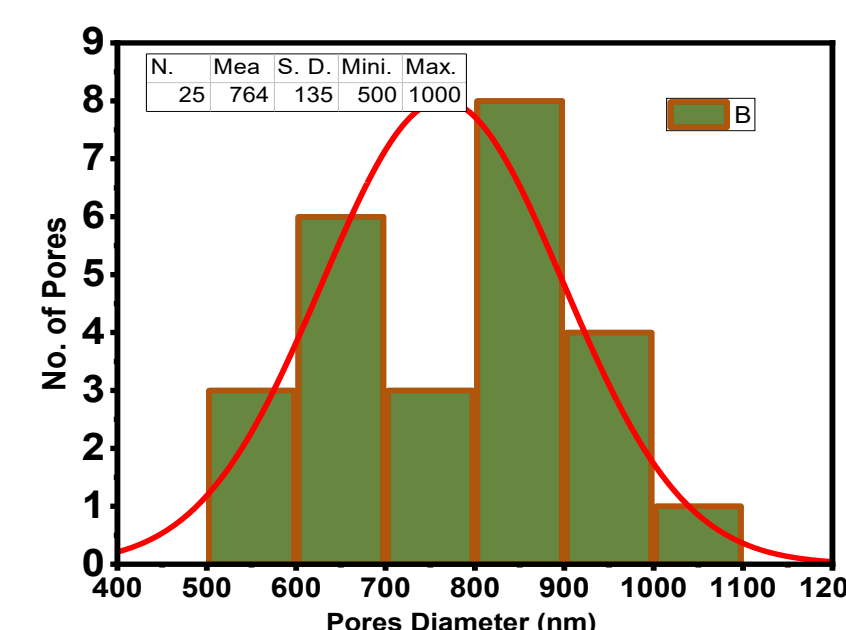


Figure 8. Histogram of pores ZnO-NPs

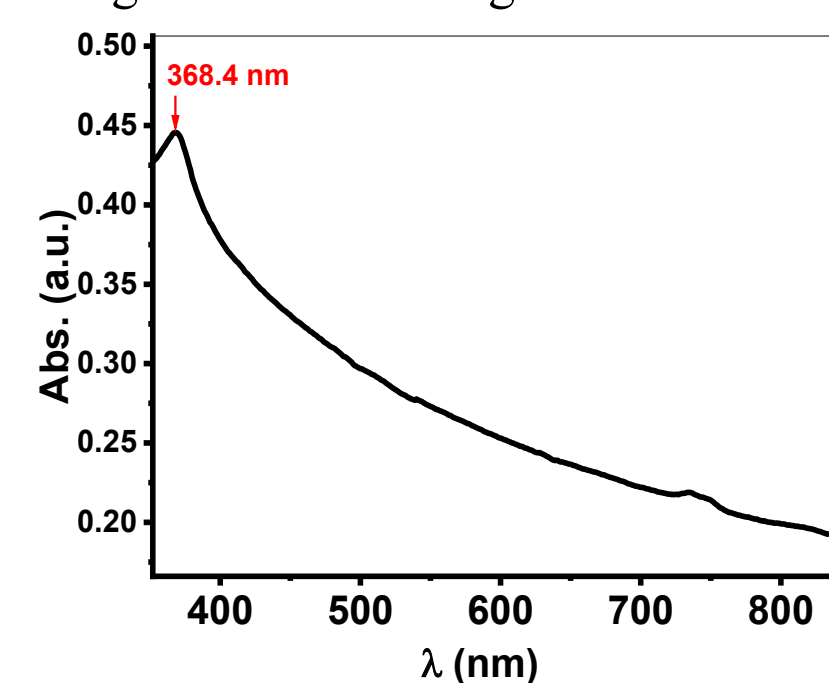


Figure 9. UV-VIS absorption spectra for ZnO-NPs.

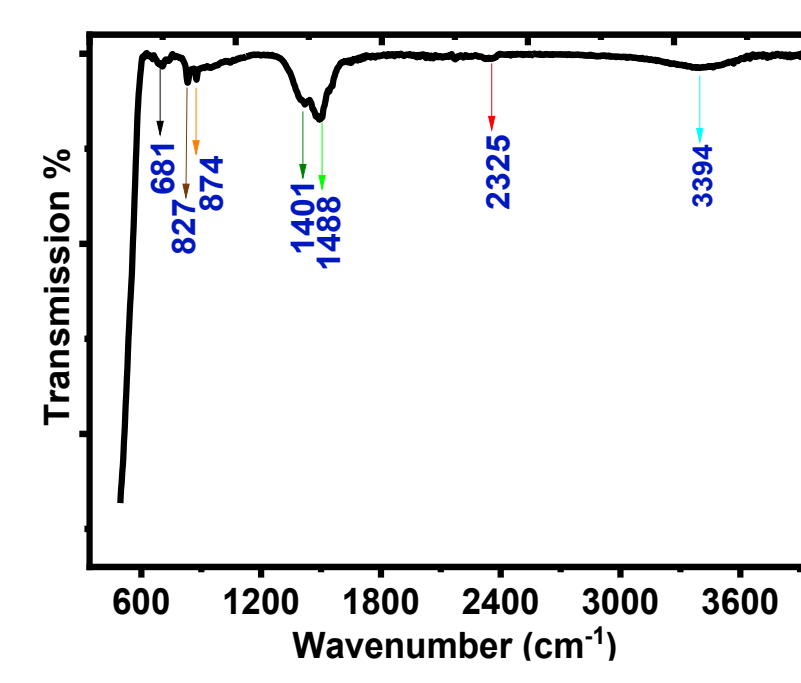


Figure 10. FTIR spectra for ZnO-NPs

CONCLUSION

- We successfully synthesized ZnO NPs using a straightforward, cost-effective, and eco-friendly combustion technique, employing a gum Arabic as an bio-organic fuel.
- The average crystallite size approximately 13.58 nm. The SSP model was concluded to provide a more realistic estimate of the crystallite size than the other models. The other models used were useful for assessing the strain, size, stress, energy density.
- The UV-VIS test confirmed a pointy absorption height at 368.4 nm indicate the formation of ZnO NPs., FTIR shows that strong and sharp peak in range of 500 cm⁻¹ was the characteristic a transmission of zinc oxide bond. SEM micrograph characterizations, were observed to be highly porous structure, possess within the diameter of 764nm.

FUTURE WORK / REFERENCES

- Study the influence of fuel-to-oxidizer ratio and combustion temperature.
- Fabricate and test gas sensors, using ZnO NPs
- Abdulqodus, A.N., et al., Green synthesis of ZnO nanoparticles: effect of pH on morphology and photocatalytic degradation efficiency. Applied Physics A, 2025. 131(9): p. 720.
- Shaht, S., et al., Solution combustion-derived ZnO nanoparticles for photoanode of solar cells. journal of Materials Science Engineering: B, 2019. 241: p. 75-81.
- Sarma, H. and K. Sarma, X-ray peak broadening analysis of ZnO nanoparticles derived by precipitation method. Int. J. Sci. Res. Publ, 2014. 4(3): p. 1-7.
- Prabhu, Y.T., et al., X-ray analysis by Williamson-Hall and size-strain plot methods of ZnO nanoparticles with fuel variation. World Journal of Nano Science and Engineering, 2014. 4(01): p. 21.