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Synthesis and Characterization of $ZnSnO_3$/PVP Composite Nanofibers for Flexible Electronics and Energy-Harvesting Applications

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INTRODUCTION & AIM

The rapid advancement of flexible and wearable electronics necessitates the development of materials that combine mechanical flexibility with excellent electrical and optical properties. Zinc tin oxide ($ZnSnO_3$), a wide bandgap semiconductor, has garnered significant attention due to its high chemical stability, tunable electronic properties, and potential for energy-related applications [1]. When integrated into a polymer matrix such as polyvinylpyrrolidone (PVP), $ZnSnO_3$ can form composite nanofibers that retain the inherent flexibility of the polymer while imparting the functional properties of the inorganic semiconductor. Electrospinning, a versatile technique for fabricating nanofibers, allows for the precise control of fiber morphology and the uniform dispersion of nanoparticles within the polymer matrix [2]. This study aims to synthesize $ZnSnO_3$ nanoparticles via a chemical precipitation method and incorporate them into PVP nanofibers through electrospinning to develop composite materials suitable for flexible electronics and energy-harvesting applications.

METHOD

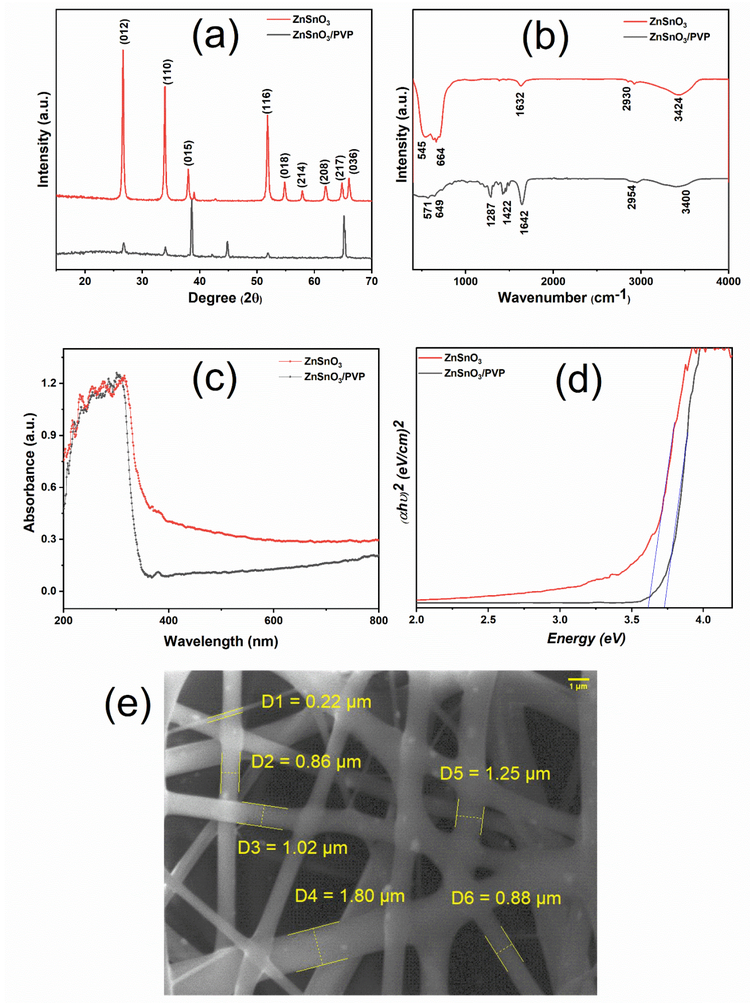
Synthesis of $ZnSnO_3$ nanoparticles:

$ZnSnO_3$ nanoparticles were synthesized via a chemical precipitation method. Zinc chloride ($ZnCl_2$) and tin(IV) chloride pentahydrate ($SnCl_4 \cdot 5H_2O$) were dissolved in deionized water under constant stirring to form a homogeneous solution. The precipitate was collected, dried at 80 °C for 12 hours, and subsequently calcined at 500 °C for 3 hours in air to enhance crystallinity and ensure stable phase formation.

Preparation of $ZnSnO_3$/PVP Electrospun Nanofibers:

For electrospinning, polyvinylpyrrolidone (PVP, Mw = 100,000) was dissolved in a solvent mixture of N,N-dimethylformamide (DMF) and acetonitrile (ACN) in a 7:3 volume ratio, with a total concentration of 21 wt%. Separately, the calcined $ZnSnO_3$ nanoparticles were dispersed in the same solvent system at a loading of 5 wt%. The dispersion was mixed with the PVP solution to form a uniform composite solution. The mixture was then loaded into a syringe and electrospun at an applied voltage of 11 kV with a tip-to-collector distance of 8 cm, resulting in as-spun $ZnSnO_3$/PVP nanofibers with smooth morphology and uniform distribution.

RESULTS & DISCUSSION



- ✓ **Fig. (a):** XRD analysis confirms $ZnSnO_3$'s orthorhombic structure (ICDD 28-1486, Pnma space group); some peaks are missing or weaker due to preferred orientation and absorption effects. PVP's amorphous nature does not appear in the XRD pattern, indicating it is well dispersed without forming separate phases.
- ✓ **Fig. (b):** FTIR results show Zn–O, Sn–O, and PVP functional groups, confirming strong interactions between nanoparticles and the polymer matrix.
- ✓ **Fig. (c) and (d):** UV–Vis spectra reveal absorbance edges at 315 nm for $ZnSnO_3$ and 304 nm for the composite, with bandgaps of 3.6 eV and 3.7 eV, showing that PVP slightly affects optical behavior.
- ✓ **Fig. (e):** FESEM images display smooth, bead-free fibers with uniform nanoparticle dispersion, suggesting excellent morphology suitable for flexible electronic and energy-harvesting devices [3].

CONCLUSION

Smooth and bead-free $ZnSnO_3$/PVP nanofibers with uniform nanoparticle dispersion were successfully synthesized by electrospinning. Their structural and optical features highlight strong potential for flexible electronic and energy-harvesting applications [4].

FUTURE WORK / REFERENCES

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