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Structural and optical properties of ZnO nanoparticles and their hybrids with CNT and PEDOT:PSS

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Introduction

- In this work, we studied the structural, morphological, and optical properties of ZnO nanoparticles, ZnO-CNT and ZnO-PEDOT:PSS nanohybrids.
- The ZnO nanoparticles were prepared using zinc acetate dihydrate (D) and zinc acetate anhydrous (A) precursors.
- The as-synthesized ZnO nanoparticles were combined with PEDOT:PSS polymer and decorated in situ on CNT.
- The samples were labelled as ZnO-D, ZnO-A, ZnO-D-CNT, ZnO-A-CNT, ZnO-D-PEDOT:PSS and ZnO-A-PEDOT:PSS.

XPS

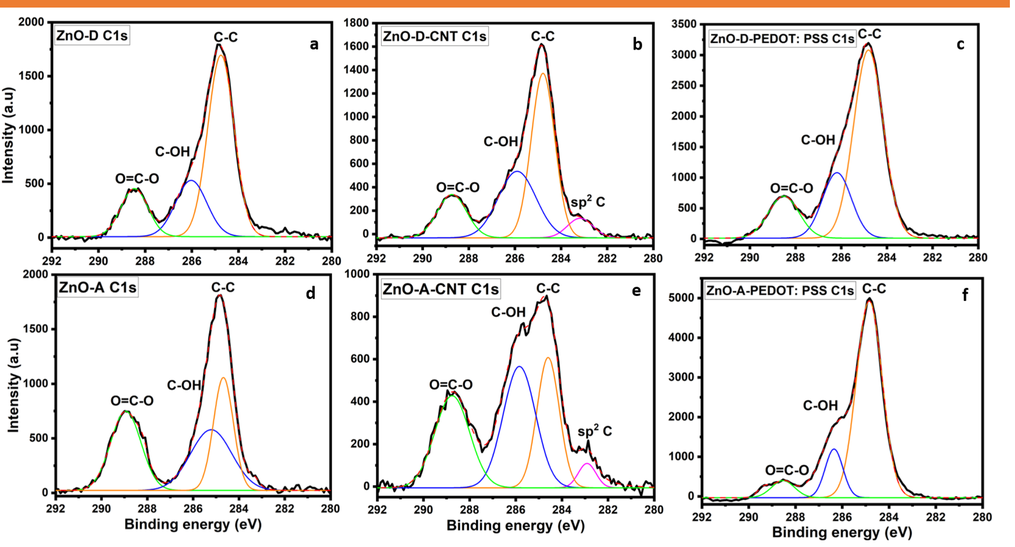

Figure 1: C1s XPS spectra of a) ZnO-D, b) ZnO-A, c) ZnO-D-CNT, d) ZnO-A-CNT, e) ZnO-D-PEDOT:PSS, f) ZnO-A-PEDOT:PSS. Major peaks: C-C, C-OH and O=C-O bonds. In ZnO-CNT samples additional sp^2 hybridized C peak of CNT are observed.

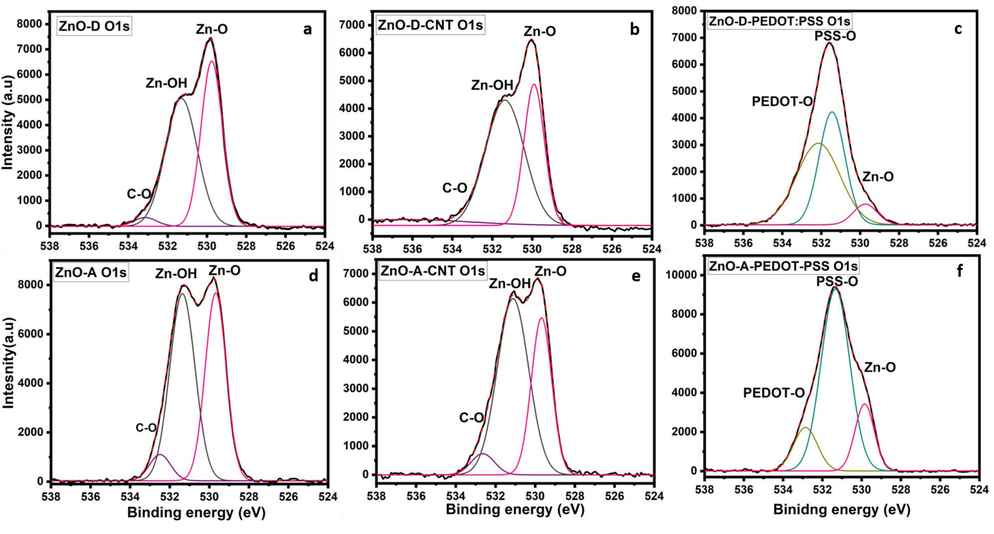

Figure 2: O1s XPS spectra of a) ZnO-D, b) ZnO-A, c) ZnO-D-CNT, d) ZnO-A-CNT, e) ZnO-D-PEDOT:PSS, f) ZnO-A-PEDOT:PSS. Major peaks: Zn-O, Zn-OH and C-O bonds. In ZnO-PEDOT:PSS samples, Zn-OH bonds are absent.

Raman spectra

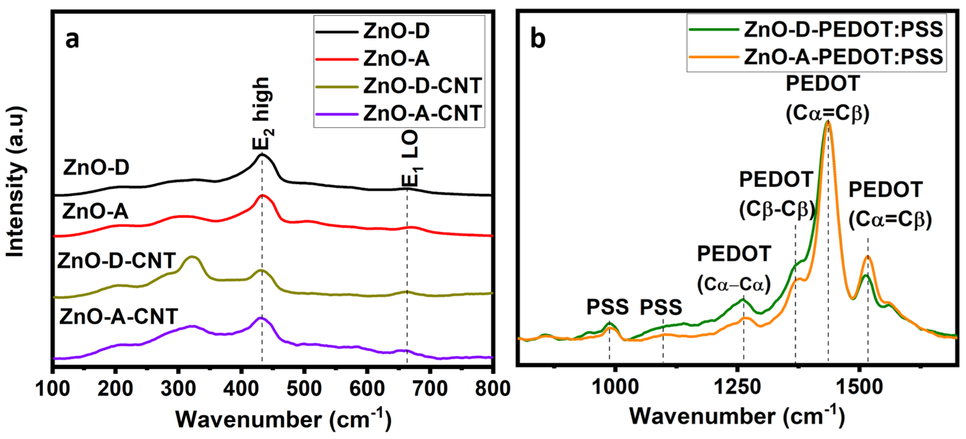

Figure 3: Raman spectra of a) ZnO-D, ZnO-A, ZnO-D-CNT, and ZnO-A-CNT, and b) ZnO-D-PEDOT:PSS and ZnO-A-PEDOT:PSS, showing differences in the peak structures and intensity. The peaks were normalized.

XRD and TEM

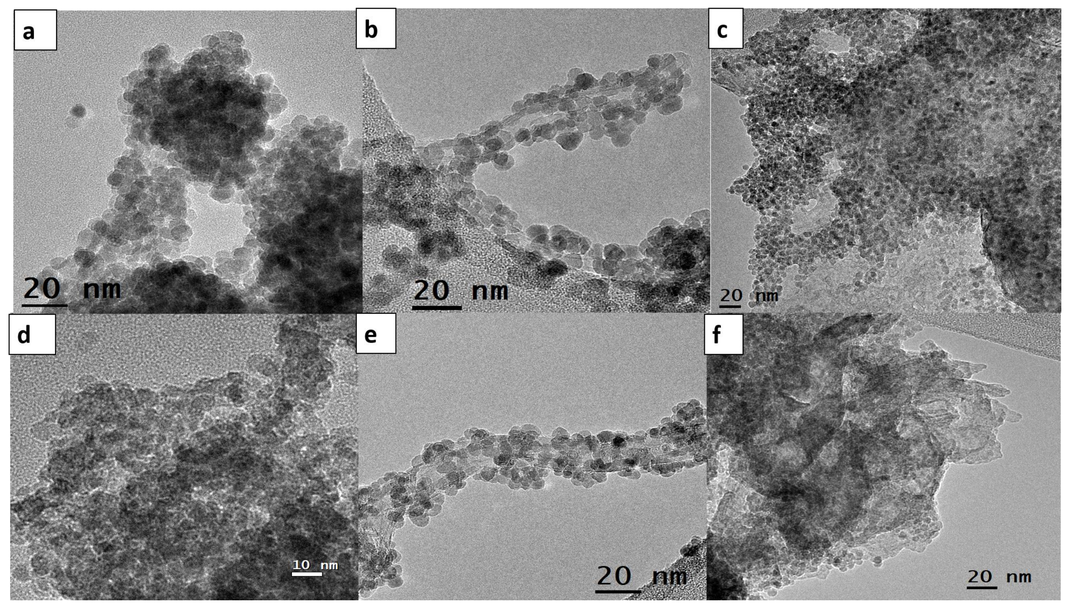

Figure 4: TEM images of sample a) ZnO-D, b) ZnO-D-CNT, c) ZnO-A-PEDOT:PSS, d) ZnO-A, e) ZnO-A-CNT and f) ZnO-A-PEDOT:PSS, showing spherical shaped nanoparticles with average size of ~5 nm. Successful CNT and PEDOT:PSS hybrid samples are produced.

Photoluminescence

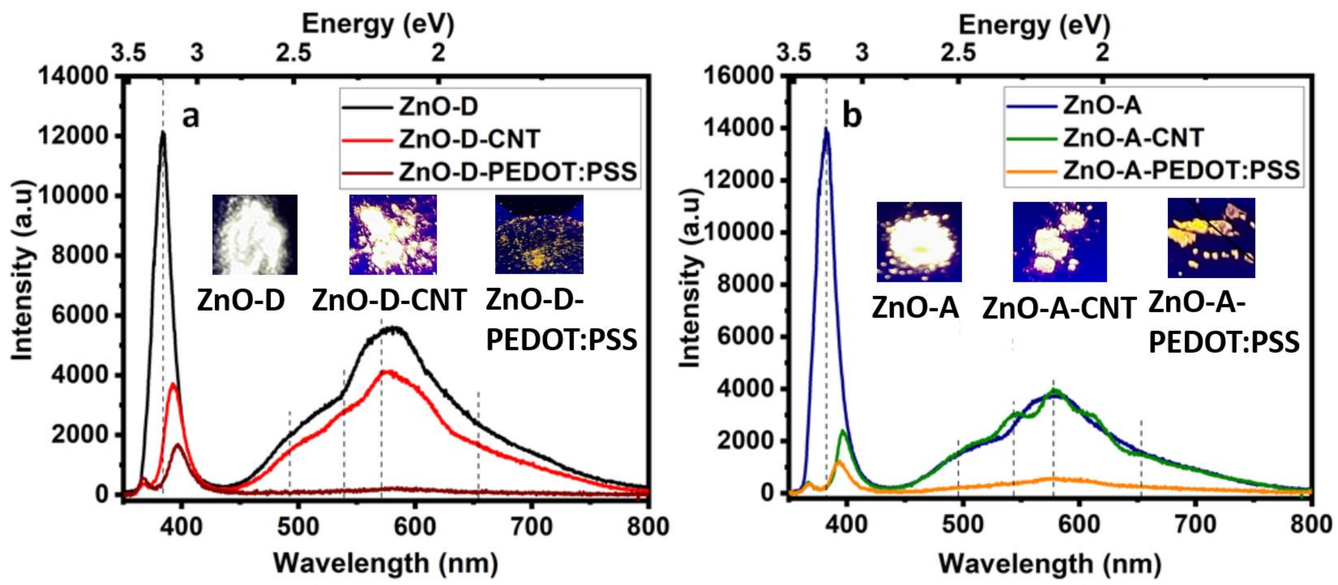

Figure 5: PL spectra of a) ZnO-D, ZnO-D-CNT and ZnO-D-PEDOT:PSS and b) ZnO-A, ZnO-A-CNT and ZnO-A-PEDOT:PSS. In both figures, it can be observed that the near band edge emission has been red shifted for ZnO-CNT and ZnO-PEDOT:PSS samples. Additionally, the defect level emission of ZnO-CNT samples persists; whereas, defect level emission of ZnO-PEDOT:PSS is passivated.

Band diagram

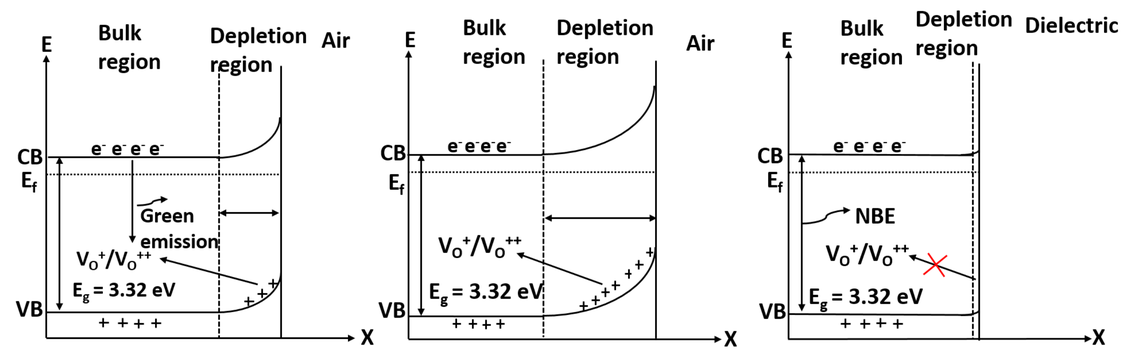

Figure 6: Band diagram of ZnO, ZnO-CNT and ZnO-PEDOT:PSS samples, explaining the effect on depletion region.

Conclusion

- Spherical shaped ZnO nanoparticles with average size of ~ 5 nm were synthesized.
- Hybrids of ZnO nanoparticles with CNT and PEDOT:PSS has shown variations in the different bonds as observed from XPS and Raman spectroscopy.
- The PL studies shows that in ZnO-CNT hybrids the defect level emission persists; whereas, passivation of defect level emission has been observed in ZnO-PEDOT:PSS hybrid.

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