Chapter 2

Synthesis, Functional Properties, and Characterization of Chalcogenide-Based Nanocomposites

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ABSTRACT

Chalcogenides exist in the form of S, Se, and Te and their nanocomposite developed with different combinations of structures and composition gaining great importance in the field of optoelectrics and energy-related applications. Hence, to identify the synthesis routes for the preparation of chalcogenide based nanocomposites from various literatures are important for developing novel chalcogenide nanocomposites, which were identified. Newly proposed chalcogenide nanocomposites with different forms such as quantum dots, core/shell, heterostructures, and nanostructures espe-

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cially in the optoelectronics and energy-field were compiled, and their properties were discussed. Efficient analytical techniques used to characterize the synthesized S, Se, and Te nanocomposites were addressed.

INTRODUCTION

Chalcogenide-nanocomposites are excellent solution for both fundamental research and technological applications in optoelectronics due to their unique optical properties as well as tuneable size and composition. These features enable revolutionize impact in photo detectors, photodiodes, photovoltaic device, and solar cells. Nanocomposites combining sulfur (S), selenium (Se), and tellurium (Te) exhibit several advantageous properties, including high surface area, tunable band gaps, broad optical absorption, third-order optical susceptibility, and low thermal conductivity, phase-change behaviour suitable for memory or switching devices, and strong photoconductivity, (Kannan & Tari, 2025). Compared to pure nanoparticles, chalcogenide-nanocomposites offer significant advantages such as improved stability, enhanced mechanical strength, and synergistic effects that result in multifunctionality, (Tari et al., 2022; Tari et al., 2025). These include better thermal stability, higher electrical conductivity, and increased catalytic activity, (Chinnaiah et al., 2025). Furthermore, chalcogenide-nanocomposites exhibit unique features such as optimized interlayer spacing, high theoretical capacity, enhanced conductivity, low operating voltage, limited ionic conductivity, and favourable ion-diffusion kinetics (Wani et al., 2025). Combined with their natural abundance, these characteristics make them attractive for electrochemical energy storage and conversion systems, (Gurushankar K. et al. 2025). Thus, tailoring their composition, dopant, and nanostructuring were becomes promising strategy for supercapacitor (Chinnaiah et al., 2025), lithium-ion, sodium-ion, and potassium-ion batteries, as well as optoelectronic devices. Some important chalcogenides are listed below.

Chalcogenide Sulphides

PbS, ZnS, FeS_2, $CuFeS_2$, HgS, Ag_2S, MoS_2, CuS, Cu_2S, Cu_5FeS_4, Sb_2S_3, Ni_9S_8. These sulphides have ultra violet (UV) to near infra-red (NIR) region spectral region for energy conversion.