

Synthesis and Characterization of CuCo_2O_4 Nanostructures-Based Hybrid Nanofluids for Enhanced Heat Transfer Applications

The growing demand for efficient thermal management in compact and high-power devices has highlighted nanofluids as promising alternatives to conventional coolants. Their performance, however, strongly depends on nanoparticle structure and suspension stability.

This PhD research investigates **carbon-modified CuCo_2O_4 spinel nanostructures** as novel nanofluid additives. The materials were synthesized via a hydrothermal method with varying carbon contents and thoroughly characterized using structural, chemical, and thermal techniques, including diffraction, spectroscopy, microscopy, surface area analysis, particle sizing, calorimetry, and synchrotron X-ray imaging. The study shows that carbon remains at the surface and grain boundaries rather than entering the spinel lattice. Moderate carbon addition (5–10 mg) improved crystallinity, porosity, and surface chemistry, resulting in stable aqueous dispersions and enhanced thermal conductivity. At ultralow nanoparticle concentrations (0.05 wt%), thermal conductivity increased by up to 20% compared to the baseline. By contrast, higher carbon loadings (20–30 mg) led to pore blockage and aggregation, reducing performance.

Overall, the work establishes clear structure–function relationships and demonstrates that carbon-modified CuCo_2O_4 nanostructures are promising candidates for **next-generation cooling systems** in microelectronics, microfluidics, and renewable energy technologies.