Chapter 6 : Conclusions and Future Perspective

6.1 Conclusion of the Present Investigation

This thesis explores lanthanide-doped $CaMoO_4$ phosphors (Er^{3+}, Yb^{3+}, Ho^{3+}, and Tm^{3+}) for temperature sensing and latent fingerprint detection. The Er^{3+} ion enabled thermally coupled level (TCL)-based temperature sensing, while Ho^{3+} and Tm^{3+} ions supported non-thermally coupled level (NTCL)-based sensing and multicolor fingerprint visualization.

Chapter 1 established the theoretical background, motivations, and potential of $CaMoO_4$ for optical applications. Chapter 2 covered synthesis via solid-state, hydrothermal, and sol-gel combustion routes, with characterization using XRD, SEM/TEM, Raman, and PL spectroscopy.

In Chapter 3, we studied Er^{3+}/Yb^{3+}: $CaMoO_4$ in bulk and nano forms, showing enhanced temperature sensitivity in nanoscale materials due to improved surface area and energy transfer. Chapter 4 introduced Bi^{3+} co-doping into Er^{3+}/Yb^{3+} systems, leading to improved upconversion and temperature sensitivity through lattice distortion and reduced non-radiative pathways. Chapter 5 demonstrated dual-functionality of $Ho^{3+}/Tm^{3+}/Yb^{3+}$: $CaMoO_4$ for NTCL-based thermometry and vivid fingerprint imaging under NIR excitation.

The thesis confirms the suitability of $CaMoO_4$ as a robust multifunctional host, capable of supporting both TCL and NTCL mechanisms. The materials synthesized and studied herein are promising for non-contact thermometry and forensic imaging.

6.2 Future Work

Building on these findings, several promising avenues for future research have been identified, aimed at further enhancing the performance of these materials and exploring new applications.

6.2.1 Development of Hybrid Materials for Advanced Applications

Hybrid Materials in Fluorides and Perovskites: Explore halide perovskites (e.g., $CsPbBr_3$) and fluoride-based systems for upconversion, anti-counterfeiting, and optical encryption applications.

6.2.2 Enhancing Luminescent Properties through Novel Strategies

- Introduce plasmonic coupling and energy transfer strategies to enhance UC emission.
- Broaden absorption cross-sections via IR dye coupling.
- Synthesize perovskite QDs for LEDs and Yb^{3+}-activated thin films for solar cells.
- Engineer emissions from Ce^{3+}/Eu^{2+} or transition metals (Mn^{4+}, Cr^{3+}, Ni^{2+}) for NIR pc-LEDs and pc-WLEDs**.**