

# White-Emitting Dy<sup>3+</sup>/Eu<sup>3+</sup> Co-Doped Fluorapatite Nanoparticles for Multispectral Biomedical Applications

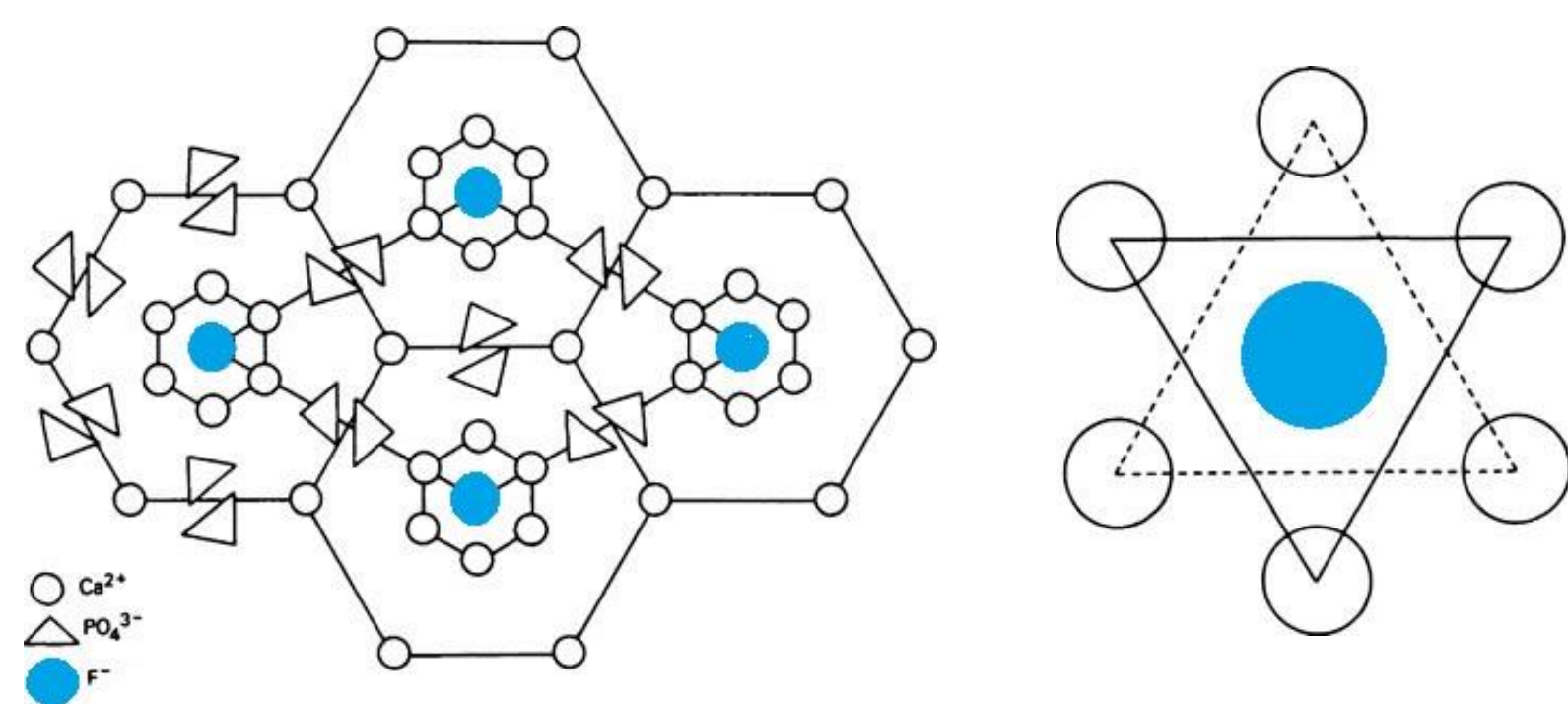
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## INTRODUCTION & AIM

Engineering luminescent nanomaterials capable of emitting stable multispectral visible light remains a key challenge in the development of advanced bioimaging technologies. While white-light emission from rare-earth co-doped phosphors has been widely explored, most existing systems rely on multi-component architectures, high-temperature synthesis routes, or host matrices with limited biocompatibility, restricting their applicability in biomedical environments. Achieving multispectral emission within a single, biocompatible, and structurally stable host therefore remains an open challenge.

In this work, a simple and low-energy room-temperature co-precipitation route ( $\approx 25^\circ\text{C}$ ) is reported for the synthesis of spherical Dy<sup>3+</sup>/Eu<sup>3+</sup> co-doped fluorapatite (Ca<sub>5</sub>(PO<sub>4</sub>)<sub>3</sub>F) nanoparticles, establishing fluorapatite as an efficient single-host platform for multispectral emission. Owing to its intrinsic biocompatibility and structural flexibility, fluorapatite enables the simultaneous incorporation of multiple rare-earth ions without compromising phase purity or crystallographic integrity ( Fig. 1.).



**Fig. 1.** Crystal structure of fluorapatite showing F<sup>-</sup> ions positioned at the center of the Ca<sub>2</sub> polyhedron.

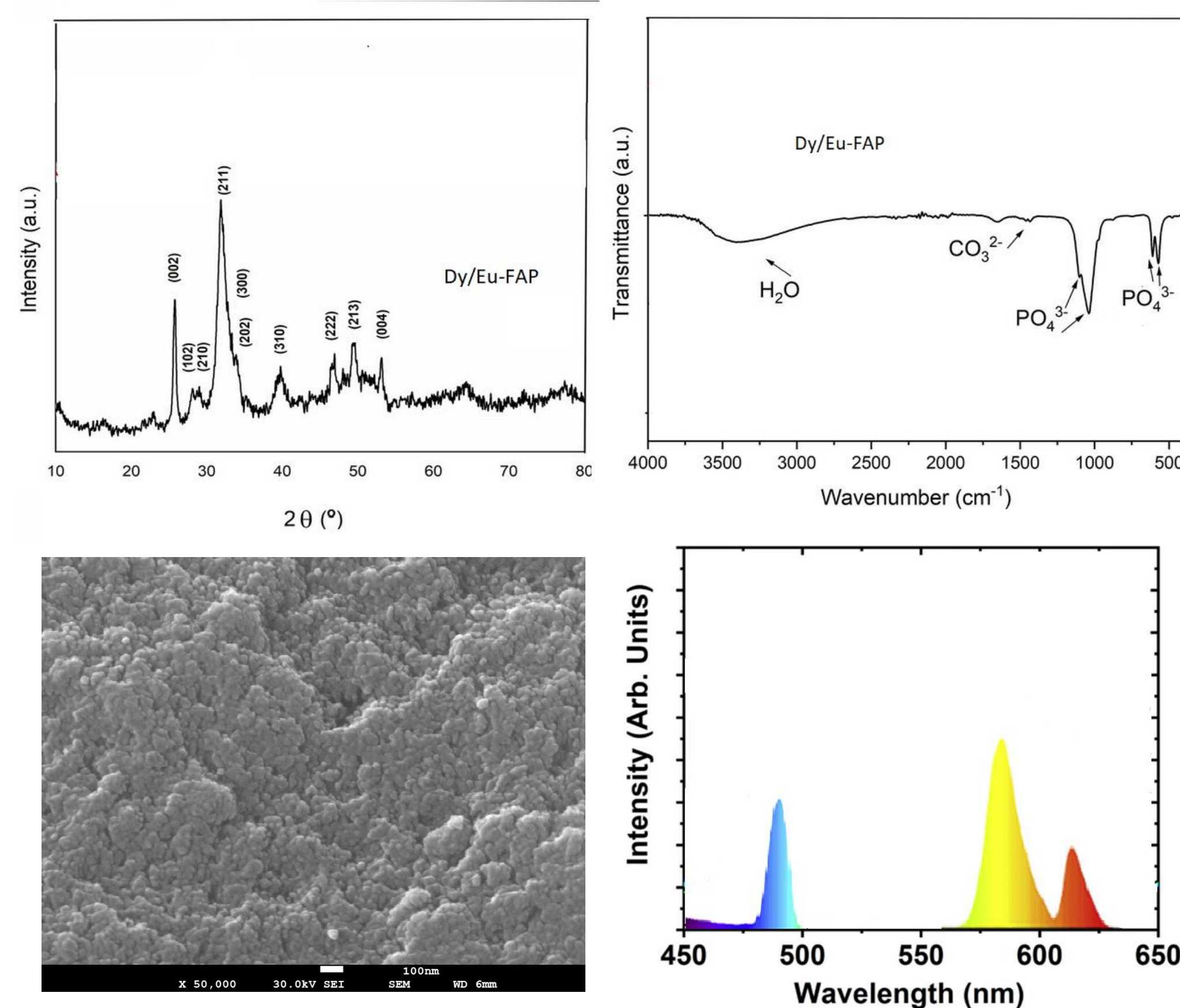
## METHOD

**Synthesis Method:** Dy<sup>3+</sup>/Eu<sup>3+</sup> co-doped fluorapatite (Ca<sub>5</sub>(PO<sub>4</sub>)<sub>3</sub>F) nanoparticles were synthesized via a simple, low-energy co-precipitation method at room temperature ( $\sim 25^\circ\text{C}$ ). Appropriate stoichiometric amounts of calcium precursor (e.g., Ca(NO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O), phosphate source ((NH<sub>4</sub>)<sub>2</sub>HPO<sub>4</sub>), fluoride source (e.g., NH<sub>4</sub>F), and dopant salts (Dy(NO<sub>3</sub>)<sub>3</sub> and Eu(NO<sub>3</sub>)<sub>3</sub>) were dissolved in deionized water. The dopant ions (Dy<sup>3+</sup> and Eu<sup>3+</sup>) were introduced into the calcium precursor solution at desired concentrations. The phosphate solution was then added dropwise under constant stirring, followed by the addition of the fluoride source to initiate precipitation. The reaction mixture was maintained under continuous stirring at room temperature for several hours to ensure complete nucleation and growth. The resulting precipitate was collected by filtration, washed several times with deionized water, and dried at moderate temperature ( $\sim 110^\circ\text{C}$ ). The obtained powders were used for further characterization without additional heat treatment.

**Characterization Techniques:** X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Field Emission Scanning Electron Microscopy (FESEM), Photoluminescence Spectroscopy (PL).

## RESULTS & DISCUSSION

Structural characterization confirms successful Dy<sup>3+</sup> and Eu<sup>3+</sup> substitution within the apatite lattice, while FESEM analysis reveals uniformly distributed spherical nanocrystalline particles (Fig 2.).



**Fig. 2.** Structural, morphological, and optical characterization of Dy/Eu-FAP performed by XRD, FTIR, FESEM, and PL techniques.

Under near-UV excitation at 380 nm, the co-doped nanoparticles exhibit combined visible emission arising from the characteristic Dy<sup>3+</sup> blue/yellow transitions and Eu<sup>3+</sup> red emission, resulting in an overall white-light appearance (Fig 2.). This combined multispectral emission enables the collection of spectral signals from multiple regions of the visible spectrum using a single nanomaterial, which is particularly advantageous for multispectral bioimaging and multiplexed detection. Importantly, this multispectral luminescence is achieved using a single excitation wavelength and a single biocompatible host matrix, eliminating the need for hybrid or multi-phase phosphor systems and reducing spectral cross-talk.

## CONCLUSION

The combination of room-temperature synthesis, intrinsic biocompatibility, spherical morphology, and single-host multispectral emission positions Dy<sup>3+</sup>/Eu<sup>3+</sup> co-doped fluorapatite nanoparticles as a versatile platform for multispectral biomedical imaging and related applications requiring stable luminescent probes.

## FUTURE WORK

- Fine-tuning of dopant concentrations to control emission profiles and color purity
- Comprehensive biological evaluation
- Extension toward advanced photonic and biomedical applications