

Post-synthetic citrate modification of Eu(III) doped hydroxyapatite nanoparticles for enhanced cellular uptake in bioimaging applications

Thoudam Chanchan Devi,^{†a} Pritam Das,^{†b,c} Souma Ghosh,^{b,c} Rajkumar Banerjee,^{*b,c} Thiyam David Singh^{*a}

^a Department of Chemistry, National Institute of Technology Manipur, Langol, 795004, India

^b Department of Oils, Lipid Science and Technology, CSIR-Indian Institute of Chemical Technology, Hyderabad, 500007, India.

^c Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, 201002, India.

Experimental procedure S1

The dependence of the zeta potential of NPs on pH for both the samples i.e. Eu:HAp and Eu:HAp@Cit was analyzed using Zetasizer Nano-ZS90 (Malvern Instruments) through electrophoretic light scattering (ELS). The experimental procedure for the zeta potential measurement was performed following the previous literature.^{S1} Briefly, the samples were first prepared at a concentration of 0.5 mg/ml in doubled distilled water and dispersed well by ultrasonication. The pH of the colloidal solution was adjusted within the range of 4–10 using dilute HCl and NH₃ solutions before being transferred to an electrophoretic cuvette. Measurements were performed at room temperature (25°C).

Reference:

S1. O. D.Shcheglov, A. P. Kussyak, A. L. Petranovska, D. I. Kravchuk, R. M. Kravchuk, Y. M. Shuba, P. P. Gorbyk, *Hybrid Advances*, 2025, 11, 100530.

Figure S1

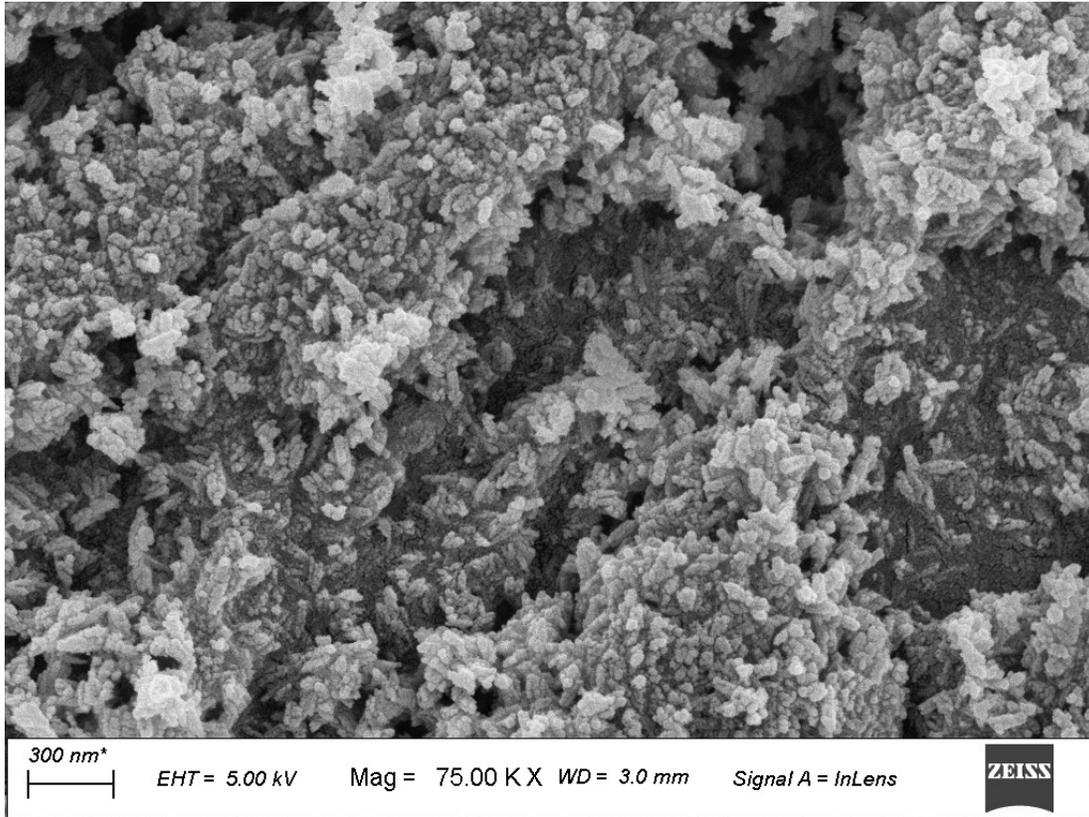


Figure S1. Higher resolution FE-SEM image of Eu:HAp NPs

Figure S2

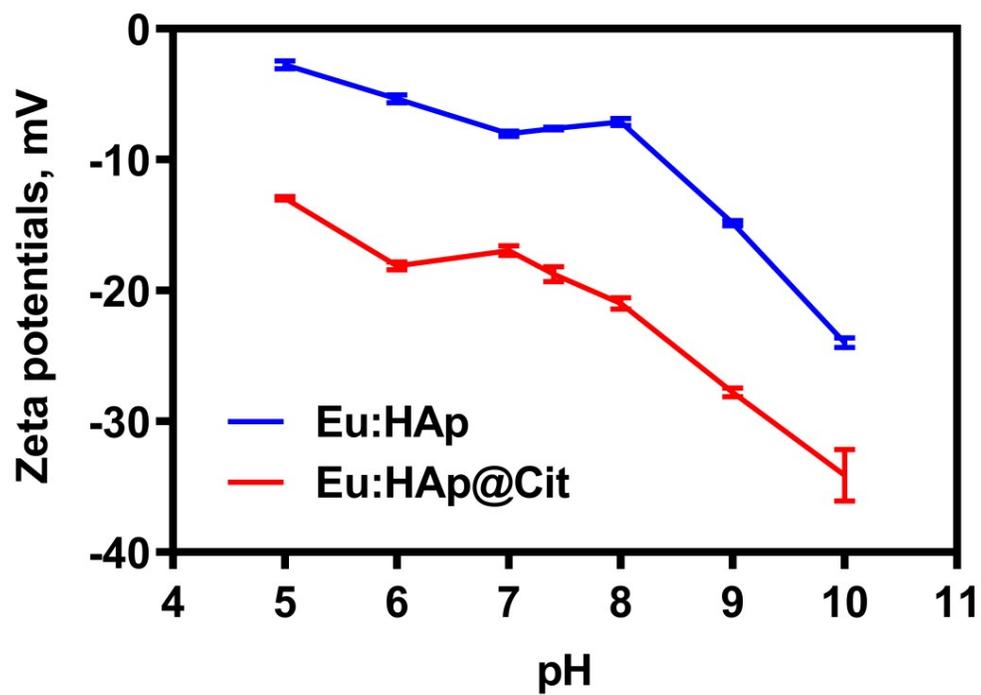


Figure S2. ζ -potential of Eu:HAp and Eu:HAp@Cit as a function of pH

Figure S3

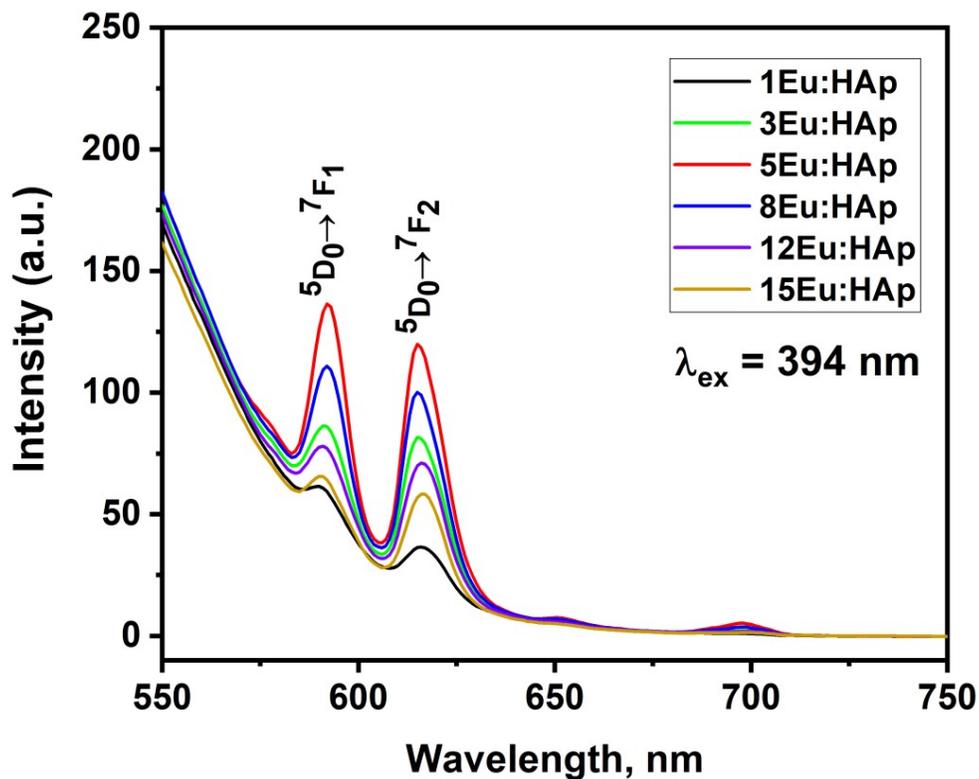


Figure S3. Photoluminescence emission spectra of xEu:HAp NPs ($x = 1, 3, 5, 8, 12$ and 15%) with varying dopant (Eu^{3+}) concentration monitored under excitation at 394 nm and the samples are coded with respect to the percentage of dopant amount

Figure S4

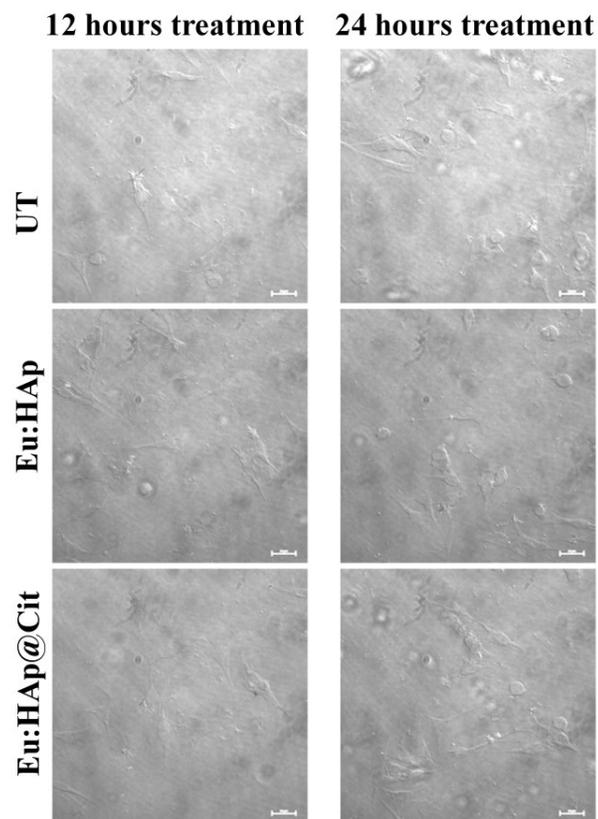


Figure S4. CLSM images of MDA-MB-231 cells showing bright field images for treatment of bared and citrate modified Eu:HAp NPs along with untreated control at two different time intervals - 12 h and 24 h treated with 400 $\mu\text{g}/\text{mL}$ of NPs. Scale bar = 20 μm .