# Supporting information

## Room Temperature Synthesis of Highly Luminescent $Eu^{3+}$ and $Tb^{3+}$ doped hexagonal-phase $YPO_4$ Nanoparticle with Tunable Emission

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# Experimental Details

## Reagents and Solutions

All the chemical used in the experiment were procured from Sigma Aldrich and were used as received. All the solutions were prepared using distilled water. The sample of $Ln^{3+}$(10%) doped $YPO_4$ (i.e., $YPO_4$:10% $Eu^{3+}$) was prepared using a coprecipitation method at room temperature. In the typical synthetic procedure of 10 % $Eu^{3+}$ doped $YPO_4$ ($YPO_4$:10% $Eu^{3+}$), 0.940 g of $YNO_3$ and 0.128g of Eu $(NO)_3.5H_2O$ were mixed together in 50 ml beaker. To this, we add 0.3105 g of $NH_4H_2PO_4$ and dissolved in 10 ml distilled water. The solution was stirred for 1hr at around 700 rpm. The precipitate so obtained was then separated by centrifugation at 12000 rpm for 5 min followed by continuously washing (4 to 5 times) with water followed by acetone. The prepared sample was finally dried at room temperature for two days.

# Instrumentation

## pXRD:

Powder X-ray diffraction patterns of samples were recorded using PAN analytical powder diffractometer (X'Pert PRO) with CuKα (1.5405Å) radiation (40kV and 30mA) with a step size of 0.02 and scan step time 0.3 s in the angular range of $2\theta = 10^o \leq 2\theta \leq 80^o$.

## Photoluminescence (PL)

Photoluminescence Emission Spectra, Excitation Spectra, Emission Lifetime and Quantum Yield of the samples were recorded at Edinburgh FLS980 Fluorimeter equipped with Multichannel Scaling (MCS) and Integrating Sphere.

## TEM

TEM images were recorded using Field Emission Transmission electron microscope (200 kv, JEOL India, Pvt, Ltd. Model :2100F).

## Supporting Figures and Tables

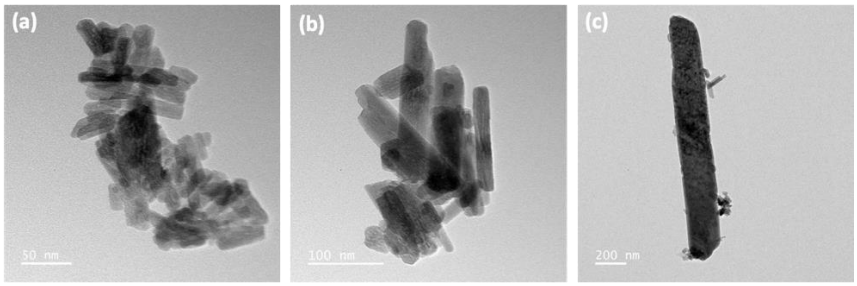


Fig. SI1 (a-c) TEM images of $YPO_4$:10% $Eu^{3+}$

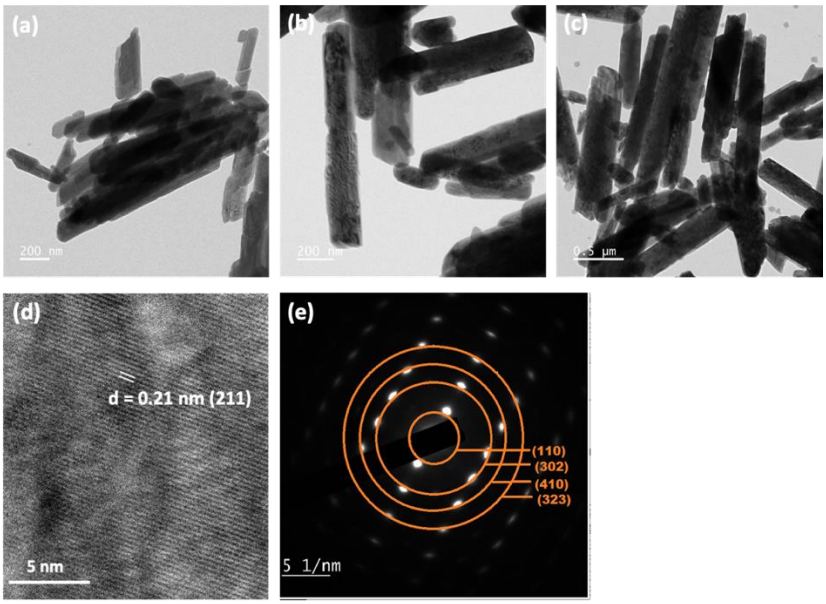


Fig. SI2 (a-c) TEM images of $YPO_4$:10% $Tb^{3+}$ (d) HRTEM image of $YPO_4$:10% $Tb^{3+}$ (e) SAED pattern of $YPO_4$:10% $Tb^{3+}$

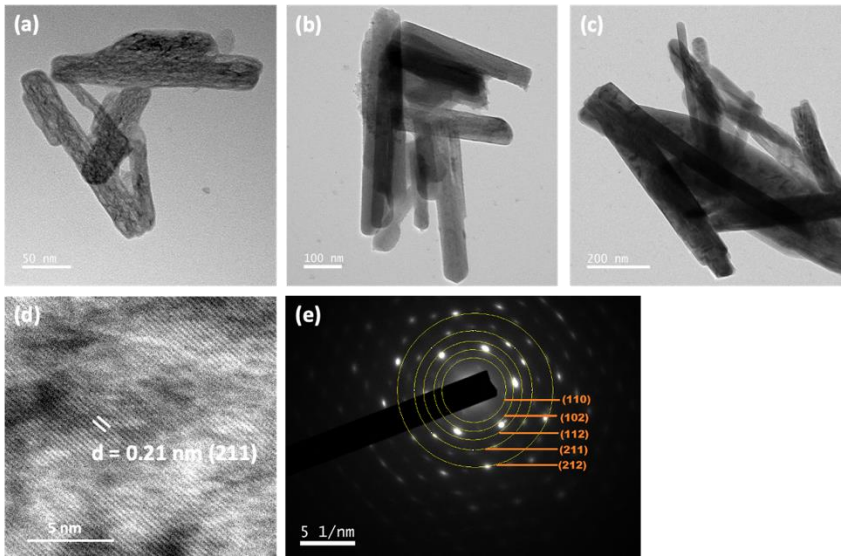


Fig. SI3 (a-c) TEM images of $YPO_4$: 7% $Tb^{3+}$, 3% $Eu^{3+}$ (d) HRTEM image of $YPO_4$:7% $Tb^{3+}$, 3% $Eu^{3+}$ (e) SAED pattern of $YPO_4$:7% $Tb^{3+}$, 3% $Eu^{3+}$

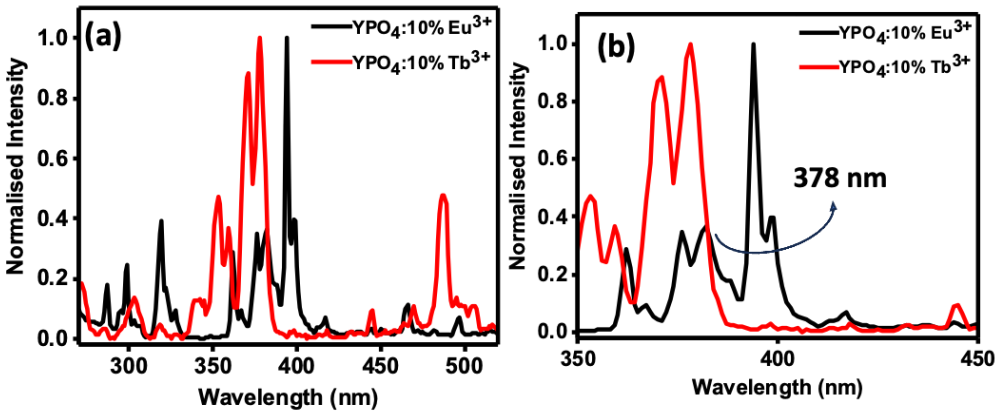


Fig. SI4 (a) Excitation spectra of $YPO_4$:10% $Eu^{3+}$ ($\lambda_{em}$ = 700 nm) and $YPO_4$:10% $Tb^{3+}$ ($\lambda_{em}$ = 545 nm) (b) Zoom out image of Fig. a, there is an overlap between $YPO_4$:10% $Eu^{3+}$ and $YPO_4$:10% $Tb^{3+}$, there is an overlap between them at 378 nm and it was used as the excitation wavelength for measuring all the emission spectra.

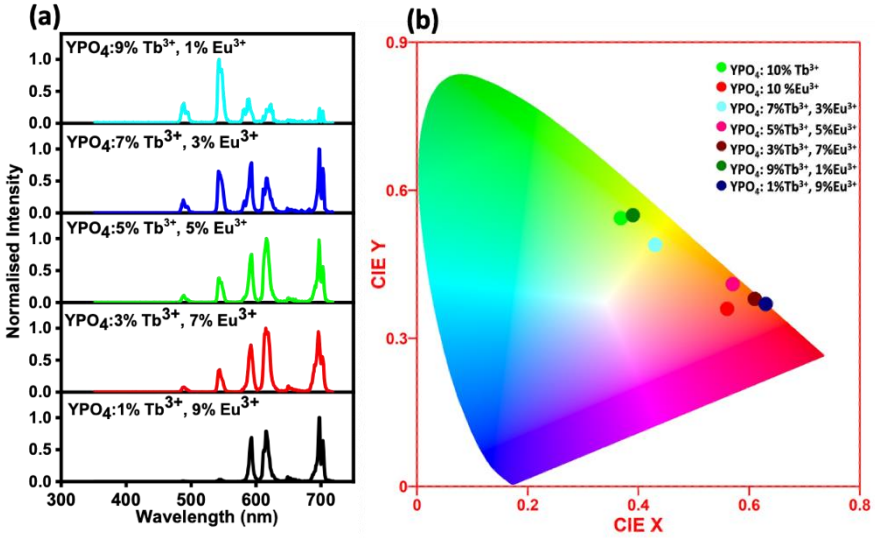


Fig. SI5 (a) Emission Spectra of $YPO_4$:$Tb^{3+}$, $Eu^{3+}$ at different Tb:Eu ratio ($\lambda_{ex}$ = 378 nm) (b) CIE plot of $YPO_4$: Tb, Eu at different Tb:Eu ratio

**Table SI1. Fluorescence Lifetime of $Tb^{3+}$ and $Eu^{3+}$**

| Samples | $\tau_1$ in µs (%) | $\tau_2$ in µs (%) | $\tau_3$ in µs (%) | $\tau_{avg.}$ in µs | $\chi^2$ |
|---|---|---|---|---|---|
| **Eu in $YPO_4$:0% $Tb^{3+}$, 10% $Eu^{3+}$** | 384.8 (99.2) | 901.8 (0.8) | 0 | 389.0 | 1.0 |
| **Eu in $YPO_4$:7% $Tb^{3+}$, 3% $Eu^{3+}$** | 426.6 (75.1) | 1405.4 (12.5) | 2979.9 (12.4) | 865.4 | 1.2 |
| **Tb in $YPO_4$:10% $Tb^{3+}$, 0% $Eu^{3+}$** | 8.6 (1.4) | 100.0 (0.2) | 1100.6 (98.4) | 1082.9 | 1.0 |
| **Tb in $YPO_4$:7% $Tb^{3+}$, 3% $Eu^{3+}$** | 9.9 (2.9) | 306.1 (9.0) | 1040.8 (88.1) | 944.6 | 1.0 |

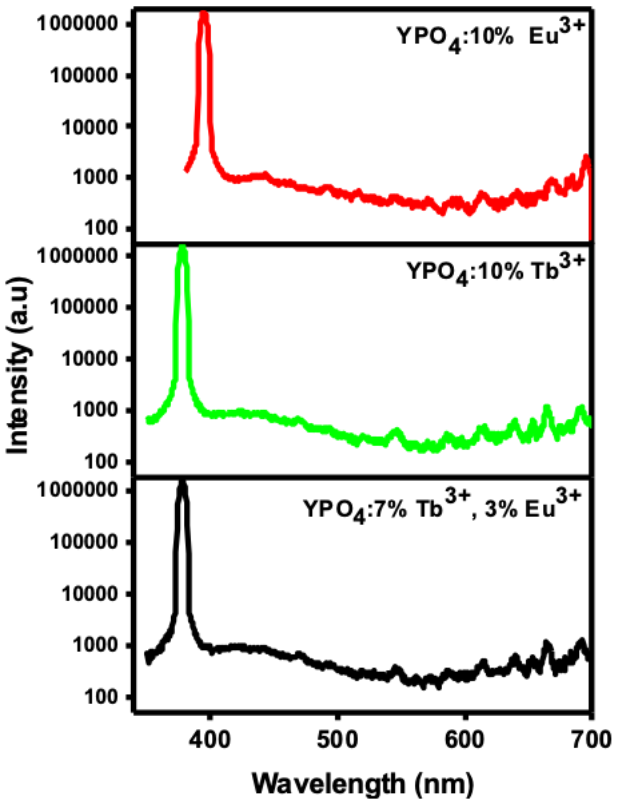


Fig. SI6. Quantum Yield plot of Ln doped $YPO_4$ nanoparticles using FLS980 Fluorimeter's Integrating Sphere

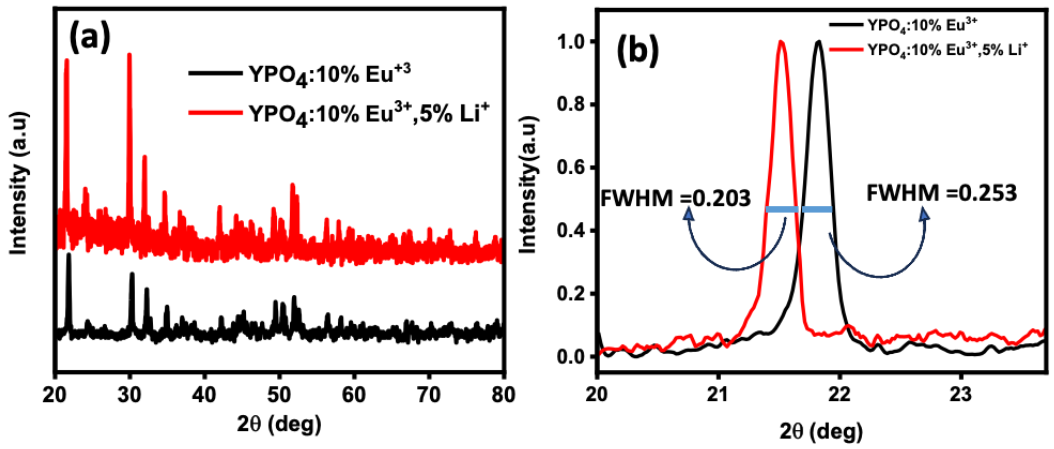


Fig. SI7 (a) pXRD spectra of $YPO_4$:10% $Eu^{3+}$ and $YPO_4$:10% $Eu^{3+}$, 5% $Li^+$ (b) Zoom out of (a), decreased in 2θ and sharper peak is evident from the decreased in full width half maxima (FWHM)

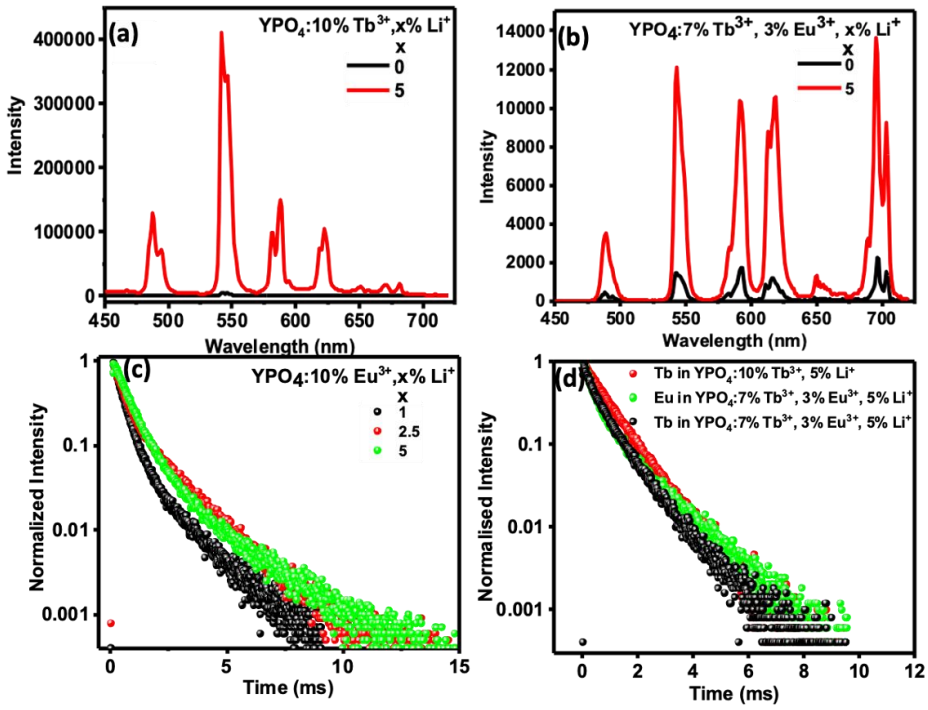


Fig. SI8 (a) Emission spectra of $YPO_4$:10% $Tb^{3+}$, 0% $Li^+$ and $YPO_4$:10% $Tb^{3+}$, 5% $Li^+$ (b) $YPO_4$:7% $Tb^{3+}$,3% $Eu^+$, 0% $Li^+$ and $YPO_4$:7% $Tb^{3+}$,3% $Eu^{3+}$, 5% $Li^+$ (c) Decay Plot of $YPO_4$:10%$Eu^{3+}$, $Li^+$, at different $Li^+$ % (d) Decay plot of Fig. (a-b).

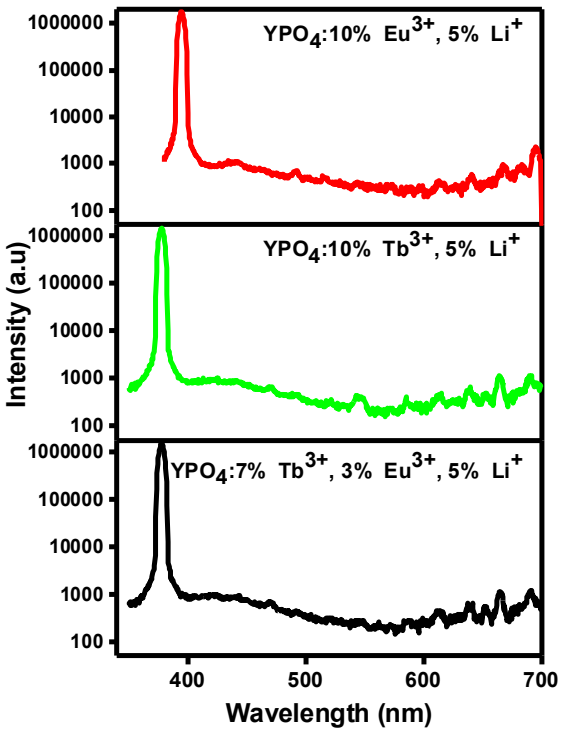


Fig. SI9. Quantum Yield plot of $Li^+$ doped $YPO_4$: Ln nanoparticles using FLS980 Fluorimeter's Integrating Sphere

**Table SI2. Fluorescence lifetime of Eu in sample Fig. SI8c**

| Samples | $\tau_1$ in µs (%) | $\tau_2$ in µs (%) | $\tau_3$ in µs (%) | $\tau_{avg.}$ in µs | $\chi^2$ |
|---|---|---|---|---|---|
| **Eu in $YPO_4$:10% $Eu^{3+}$, 1% $Li^+$** | 2.0 (0.1) | 397.0 (72.0) | 1564.1 (28.0) | 723.1 | 1.3 |
| **Eu in $YPO_4$:10% $Eu^{3+}$, 2.5% $Li^+$** | 20.0 (0.1) | 432.5 (44.7) | 1664.7 (55.3) | 1113.3 | 1.2 |
| **Eu in $YPO_4$:10% $Eu^{3+}$, 5% $Li^+$** | 571.9 (56.7) | 905.8 (22.9) | 2422.6 (20.4) | 1026.3 | 1.3 |

**Table SI3. Fluorescence lifetime of Eu in sample Fig. SI8d**

| Samples | $\tau_1$ in µs (%) | $\tau_2$ in µs (%) | $\tau_3$ in µs (%) | $\tau_{avg.}$ in µs | $\chi^2$ |
|---|---|---|---|---|---|
| **Tb in $YPO_4$:10% $Tb^{3+}$, 5% $Li^+$** | 2.5 (0.1) | 425.0 (0.2) | 1321.4 (99.7) | 1318.6 | 1.0 |
| **Tb in $YPO_4$:7% $Tb^{3+}$, 3% $Eu^{3+}$, 5% $Li^+$** | 8.6 (0.1) | 800.1 (44.4) | 1383.3 (55.5) | 1123.5 | 1.2 |
| **Eu in $YPO_4$:7% $Tb^{3+}$, 3% $Eu^{3+}$, 5% $Li^+$** | 3.9 (0.1) | 663.0 (38.8) | 2522.5 (61.1) | 1799.2 | 1.2 |