Ce$^{3+}$ sensitized Ln$^{3+}$-doped nanocrystals for sensing and light emitting applications

Venkataramanan Mahalingam$^1$, Venkata. N. K. B. Adusumalli$^1$, Heramba V. S. R. M. Koppisetli$^1$, Shyam Sarkar$^1$, Manjunath Chatti$^1$

$^1$Department Of Chemical Sciences IISER Kolkata, Nadia, India
E-mail: mvenkat@iiserkol.ac.in

The scientific quest towards lanthanide (Ln$^{3+}$)-doped nanomaterials is continuously growing which is largely attributed to the unique optical properties resulting from their inner 4f electrons. The intra 4f-4f transitions from Ln$^{3+}$ ions span a wide optical window (say from UV to near infrared). In addition to the generally observed Stokes emission, they exhibit interesting anti-Stokes emission known as upconversion process, where one or more low energy photons combined to produce high energy light. However, the Ln$^{3+}$-doped nanocrystals suffer from low quantum efficiency due to forbidden nature of the intra 4f transitions. Our objective of the increase the luminescence quantum efficiency of Ln$^{3+}$ ions via energy transfer. Both Ce$^{3+}$ and Yb$^{3+}$ are good sensitizers for enhancing the luminescence via Stokes and upconversion process, respectively. This talk will cover discussion on Ce$^{3+}$/Ln$^{3+}$ (Ln = Tm, Tb and Sm)-doped nanocrystals for developing blue and white light emitting materials and their use in the fabrication of transparent nanocomposites by incorporating them in polymer matrix. The energy transfer mechanism between Ce$^{3+}$ and some of the Ln$^{3+}$ ions which led to the production of white light emission is shown in the below image. In addition, the talk covers the use of Ce$^{3+}$/Tb$^{3+}$-doped SrF2 nanocrystals for the detection of Cu$^{2+}$ ions at the nanomolar concentration. Finally, the talk will cover how the Ce$^{3+}$ to Ln$^{3+}$ energy transfer can be tuned via phase change by taking NaYF4 as host for the lanthanide ions. In fact, the study provides new insight that the energy transfer efficiency between Ce$^{3+}$ and Ln$^{3+}$ ions is higher in cubic phase NaYF4 nanocrystals compared to hexagonal phase nanocrystals due to difference in crystal field splitting of the 4f5d level of Ce$^{3+}$ ions.


Keywords: lanthanides, luminescence, white light