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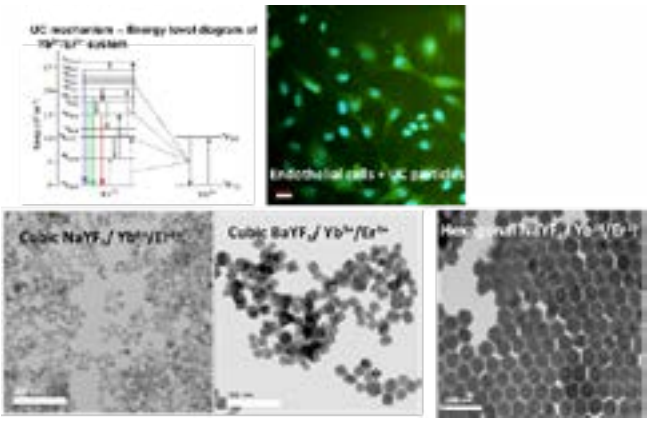
Synthesis of upconversion nanoparticles for advanced biomedical applications

Upconversion nanoparticles (UCNPs), doped with rare earth ions convert a longer wavelength infrared (IR) radiation (800-1100 nm) to shorter wavelength fluorescence (400 to 700 nm). Upconversion (UC) is an anti-stokes process, which relies on the presence of multiple metastable excited states, thus leads to enhanced photophysical properties. The UCNPs possess attractive features including high signal-to-noise ratio, high photostability, weak autofluorescence, deep tissue penetration depth and low toxicity. Many of the nanocrystals combine novel optical properties with simple preparation techniques and offer the scope of tuning the materials structure or composition to give desired emission profiles making them attractive for use in a broad range of applications. UCNPs are ideal platforms for different functionalities that can be integrated within a single system upon proper choices of particle matrix and dopants. Synthesis method and variation in synthesis parameters affects the basic properties such as crystal phase, particle size and fluorescence intensity. In this study, UCNPs with $NaYF_4$ (host lattice) doped with Yb^{3+} (sensitizer) and Er^{3+} (activator), were fabricated via hydrothermal synthesis incorporating polyethyleneimine for long-term UCNP stability in water. Transmission electron microscopy showed the size of the UCNPs to be 15-20 nm. The non-toxicity of the UCNP in endothelial cells has been established, which confirms the suitability of the UCNP for cellular imaging. Correlation of fluorescent image features and spectral characteristics in the visible region under NIR laser excitation at 980 nm along with material properties are reported in the present study. Hexagonal nanoparticles are also been synthesized and basic structural characterizations are being executed, showing higher green luminescence, while exciting at 980 nm. Variation in structural aspects with change in host ($BaYF_5$) has been studied and $BaYF_5$ /Yb3+/Er^{3+} particles could find application as CT contrast agents too. The results of these studies will be useful for adopting UCNPs in future *in vivo* and multimodal imaging applications.



Recent Publications

1. Zhou B, Shi B, Jin D and Liu X (2015) Controlling upconversion nanocrystals for emerging applications. Nature Nanotechnology 10:924-936.
2. Chen G, Qui H, Prasad P N and Chen X (2014) Upconversion nanoparticles: Design, nanochemistry and applications in theranostics. Chemical Reviews 114:5161-5214.
3. Dong H, Sun L D and Yan C H (2013) Basic understanding of the lanthanide related upconversion emissions. Nanoscale 5:5703-5714.
4. Shen J, Sun L D and Yan C H (2008) Luminescent rare earth nanomaterials for bioprobe applications. Dalton Transactions 42:5687-5697.
5. Chatterjee D K, Gnanasammandhan M K and Zhang Y (2010) Small upconverting fluorescent nanoparticle for biomedical applications. Small 6:2781-2795.

Biography

Padmaja Parameswaran Nampi received her PhD in 2003 from National Institute for Interdisciplinary Science and Technology of the Council for Scientific and Industrial Research, India (Mahatma Gandhi University, Kerala, India). She worked as Postdoctoral Research Scientist at the National Institute of Advanced Industrial Science (AIST), Nagoya, Japan during 2004-2006. She worked as Senior Research of CSIR and Principal Investigator of Department of Science and Technology, Government of India at Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST) in collaboration with University of Leeds, UK. Currently, she is a Marie Skłodowska-Curie Experienced Researcher at the School of Chemical and Process Engineering, University of Leeds, UK. Her current research interest includes nanomaterials, mainly upconversion nanomaterials for various biomedical applications such as biosensing and bioimaging.

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