Lanthanide-Based Nanoparticles – From Synthesis to Sensors

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The optical properties of lanthanide (Ln) ions make Ln-based materials attractive for applications ranging from biomedicine to optomagnetic, optoelectronic, and energy conversion technologies. Their unique electronic structure enables upconversion, i.e., the emission of UV-visible light under near-infrared (NIR) excitation. In addition, some Ln-based materials emit in the NIR under NIR excitation, operating entirely within the so-called NIR transparency window, which is particularly attractive for biomedical applications.

Sodium lanthanide fluorides ($NaLnF_4$) are a well-established host material, and we have developed a microwave-assisted synthesis that enables control over crystal phase and particle size below 20 nm. With this fast and reliable synthetic route, we now explore different nanoparticle architectures and compositions to optimize optical and magnetic properties, with the aim of developing brighter emitters, biocompatible multimodal imaging probes, and nanoscale thermal sensors. In parallel, alternative host materials for upconverting Ln^{3+} dopants are being investigated, including new synthetic routes to lanthanide fluorides, oxyfluorides, and oxysulfides.

This presentation provides an overview of Ln-based materials with a focus on microwave-assisted synthesis and nanoparticle design for imaging and thermal sensing applications. In the context of thermal sensing, recent results on the cross-sensitivity of luminescence intensity ratios will be discussed, highlighting potential limitations and suggesting more reliable alternative strategies.

Bio Sketch:

Dr. Eva Hemmer is an Associate Professor and University Research Chair in Materials Chemistry at the University of Ottawa, Canada. She received her PhD in Materials Science from Saarland University, Germany, in 2008 under the mentorship of Prof. Sanjay Mathur, where she worked on the synthesis of lanthanide alkoxides and their decomposition into lanthanide-containing inorganic nanomaterials. She then joined Prof. Kohei Soga's group at the Tokyo University of Science for her first postdoctoral position (2009–2012), focusing on lanthanide-doped nanoparticles for near-infrared bioimaging.

From 2012 to 2016, she was a postdoctoral fellow at INRS-EMT (Montréal), Université du Québec, working with Profs. Fiorenzo Vetrone and François Légaré on nanothermometers based on upconverting nanoparticles. In 2013, she was awarded a Feodor Lynen Research Postdoctoral Fellowship from the Alexander von Humboldt Foundation in support of this work. In winter 2016, she joined the Department of Chemistry and Biomolecular Sciences at the University of Ottawa as an independent researcher, where she established her research program on lanthanide-based nanomaterials for applications ranging from biomedicine to advanced optical materials.

Her work and contributions to the materials community have been recognized with the 2021 ACerS Jubilee Global Diversity Award, the 2021 NanoOntario Early-career Achievement Award in Nanoscience and Nanotechnology, the ACerS Du-Co Ceramics Young Professional Award, and the University of Ottawa's 2024 Early Career Researcher of the Year Award. She has also been active in the broader materials community through the American Ceramic Society and the Materials Research Society, where she currently serves as Chair of the Student Engagement Sub-Committee.

Since February 2024, Eva has served as an Associate Editor for *Nanoscale* and *Nanoscale Advances*.

