Shining a Light on Lanthanide-Doped Nanoparticles: From Synthesis to Potential Applications

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The remarkable optomagnetic properties of the rare-earth elements (RE) make RE-based materials ideal for biomedical applications, including diagnostic (e.g., imaging, nanothermometry) and therapeutic (e.g., drug delivery, photodynamic therapy) approaches. This is due to the unique electronic properties of the f-elements allowing for upconversion and near-infrared emission under near-infrared excitation as well as high magnetic moments. Moreover, the temperature dependence of their optical features allows to use RE-based materials as nanothermometers for optical temperature read-out. Yet, challenges remain. Low emission intensity and efficiency of small nanoparticles (NPs), and reliable, fast synthesis routes. As material chemists, we tackle these challenges with new designs of RE-NPs by chemically controlled synthesis, application-oriented surface chemistry, and understanding of structure-property-relationships. Sodium rare-earth fluorides ($NaREF_4$) are our favorite materials, and we developed a fast and reliable microwave-assisted synthesis approach allowing crystalline phase and size control in the sub 20 nm realm.[1] Such control is crucial for the understanding of fundamental structure-property relationships and to optimize their optical and magnetic properties, when aiming for the design of next-generation optical probes or contrast agents for magnetic resonance imaging. For instance, $NaGdF_4$ NPs are gaining interest as alternative MRI contrast agents,[2] while co-doping with luminescent RE^{3+} ions renders them excellent candidates for photoluminescent optical probes. Having a fast and reliable synthesis route towards $NaREF_4$ NPs on hand, we now explore various nanoparticle architectures and compositions with the goal to optimize their optical properties, ultimately resulting in the design of biocompatible multimodal bioprobes.[3,4] This presentation will shed light on recent results and remaining challenges in the field of RE-based nanostructures with respect to their microwave-assisted synthesis as well as structural and optical properties, seeking biomedical (and beyond) application.

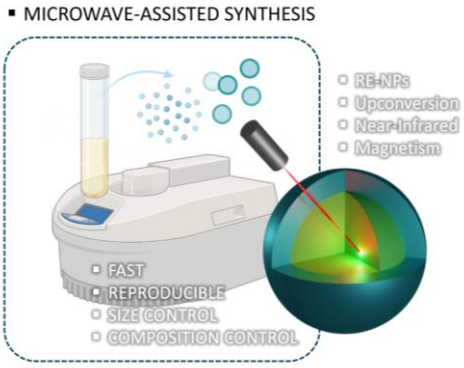

Figure 1. Microwave-assisted synthesis of multifunctional rare-earth-based nanomaterials.

References

[1] I. Halimi, E. M. Rodrigues, S. L. Maurizio, T. Sun, M. Grewal, E. M. Boase, N. Liu, R. Marin, Eva Hemmer, J. Mater. Chem. C, 7 (2019) 15364.
[2] N. Liu, R. Marin, Y. Mazouzi, G. O. Cron, A. J. Shuhendler, E. Hemmer, Nanoscale, 11 (1019) 6794.
[3] N. Liu, C. Homann, S. Morfin, M. Kesanakurti, N. Calvert, A. J. Shuhendler, T. Al, E. Hemmer, Nanoscale, 15 (2023), 19546.
[4] A. Puccini, N. Liu, E. Hemmer, ACS Materials Lett., 6 (2024), 1327.