Nanoparticles showing persistent up-conversion luminescence – synthesis and characterization of properties

Nanoparticles with sizes not exceeding several tens of nanometers are of primary interest to numerous research groups around the world. Such small objects whose size can be up to 10 000 times smaller than the diameter of human hair have unique properties which currently are used in electronics, lighting, energy production, in the preparation of other materials as catalysts, and as security markers in documents such as ID cards and banknotes. One of the most important features of nanoparticles is their small size, which allows them to be placed in cells and living organisms for the diagnosis and treatment of cancer, but not only. The bioapplications would not be possible without the luminescent properties of nanoparticles.

The planned project research concerns nanoparticles showing luminescence under the irradiation with infrared light. What is unusual, these nanoparticles will show a persistent (long-lasting) luminescence, i.e. one that can last up to several hours after exposure. Currently available materials with long-lasting luminescence must be irradiated with ultraviolet or visible radiation. To achieve this goal, the up-conversion phenomenon will be used. Due to the physicochemical properties of some of the lanthanide ions (Ln^{3+}), which will be an admixture in the structure of the synthesized nanoparticles, irradiating them with infrared light results in the absorption of two or more photons and their conversion to photons with higher energy than the absorbed. This conversion is seen in the emission of light with a wavelength, most commonly, from ultraviolet to red. Thanks to the properly designed systems, the up-conversion to ultraviolet can be used to excite this part of the nanostructure, which is capable of persistent luminescence. Such nanohybrids can exhibit characteristics of both forming them systems and give a resultant effect, studied in the project, i.e. persistent up-conversion luminescence.

The nanoparticles resulting from the project realization are particularly important for the development of imaging techniques for cancer diagnosis and treatment. The modified nanoparticles can be irradiated before being placed in the living organism, which eliminates the need for irradiation during the investigation and analysis. An important feature of the studied nanoparticles is the possibility of “recharging” in the organism, as infrared radiation is largely transmitted through the tissue. This is not possible in classic materials with long-lasting emission, excitable by ultraviolet.

To achieve the project's objectives, it is planned to synthesize nanoparticles with many combinations of their structures, such as core/shell and hollow structures with a luminescent core inside. Besides, homogeneous structures containing ions giving them long-lasting emission and enabling the possibility of up-conversion in a single phase, as well as mesoporous systems in which nanoparticles with two different types of emission will be placed in pores are also planned.

The project will be carried out in cooperation between scientists from the Faculty of Chemistry at the Adam Mickiewicz University in Poznań, the Institute of Low Temperature and Structural Research of the Polish Academy of Sciences in Wrocław, as well as scientists from Spain, the University of La Laguna and France from the Paris-Saclay University.