Luminescence of Lanthanide Ions in Coordination Compounds and Nanomaterials

Lanthanide, Ln^{III}, ions are used in a wide range of photonic applications, which now extend from physics to materials science, agriculture, biology, and medicine. Lasers, optical amplifiers, phosphors for lighting and displays, guiding devices, security inks, counterfeiting tags, luminescent coatings, probes for luminescence immunoassays, and biological medical imaging and sensing are all applications that rely on Ln^{III} luminescence. That is the subject of this book, which is edited by Ana de Bettencourt-Dias and written by world leaders in the different research areas.

To take full advantage of the luminescent properties of Ln^{III} ions and to design probes or materials with desired functions, it is important to understand the basics of Ln^{III} spectroscopy. The first chapter describes electronic configurations of these ions and the theory of f–f transitions and their sensitization mechanisms. The special optical properties of Ln^{III} ions offer important opportunities, but also present challenges for the correct gathering and interpretation of luminescence data. The second chapter provides a broad overview of spectroscopic instrumentations, and methods used to measure emission and excitation spectra, luminescence lifetimes, and quantum yields. It also describes recent advanced approaches to explore Ln^{III}-based luminescent nanomaterials.

Chapter 3 introduces the use of circularly-polarized luminescence (CPL) and instrumentation, and describes recent studies aimed at establishing correlations between the chiral structure of Ln^{III}-containing complexes and their CPL properties.

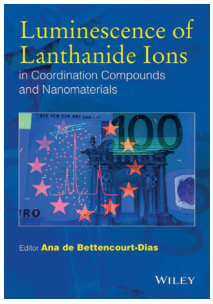
Optical imaging, in particular luminescence-based imaging, is an emerging technology with a great potential for improving the diagnosis of diseases, and the choice and assessment of different medical treatments. The ability of optical imaging to detect, localize, and monitor in real time critical processes in living cells, tissues, and whole biological organisms is essential for the development of predictive personalized medicine. Ln^{III}-based imaging probes provide complementary advantages over the use of organic fluorophores or semiconductor nanoparticles, enabling easy spectral and time discrimination, while also being strongly resistant to photo-bleaching. Chapters 4 and 5 review biological imaging experiments using Ln^{III} complexes and single- or multi-photon excitation, respectively. Optical imaging with up-converting nanoparticles is described in Chapter 7. Features of the design, synthesis, and characterization of each of the types of Ln^{III}-based imaging probes are presented in detail in each chapter. In Chapter 4, the reader can also find information about the main principles of luminescence microscopy and microscope set-ups, with particular attention to time-resolved detection.

Chapter 6 focuses on the design of chemosensors. Ln^{III}-based complexes can be used for the measurement of pH, concentrations of key anions and cations, and interactions with DNA or other biological molecules with high sensitivity and controlled selectivity.

For most practical applications, in order to achieve high efficiency Ln^{III} ions are usually excited through chromophoric ligands. However, the complexity of the energy transfer processes and the existence of numerous non-radiative pathways may lead to a misleading interpretation of the experimental data, which makes it challenging to obtain reliable information about the coordination environment of the Ln^{III} ions. In this situation, the direct excitation of Ln^{III} ions becomes a powerful technique to gather details about inner- and outer-sphere interactions with neighboring molecules, to define changes in hydration numbers and speciation in solution, to detect the formation of aggregates, etc. Such information can be essential for a better understanding of the mechanisms of action of sensors and catalysts, or of the behavior of biological imaging probes. These techniques are described in Chapter 8.

The design of d–f, f–f, and s–f heterometallic lanthanide-based luminescent complexes and the challenges of synthesizing them are dealt with in Chapter 9. The coupling of different metal ions within one molecule to provide different functionalities opens a way to multimodal imaging. Moreover, heterometallic complexes can be self-assembled in vivo, although the understanding of this process is still in its infancy.

In conclusion, all of the book's chapters combine both instructive and critical review aspects, and thus can be equally helpful and inspiring, not only for newcomers but also for experienced researchers seeking to bring cutting-edge developments into the field of Ln^{III} luminescence and its applications.



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