

Book Review of Lanthanide Luminescence: Photophysical, Analytical, and Biological Aspects

Lanthanide Luminescence: Photophysical, Analytical, and Biological Aspects. Edited by Pekka Hänninen and Härmä Harri (University of Turku, Finland). From the Springer Series on Fluorescence, 7. Edited by O. S. Wolfbeis. Springer: Heidelberg, Dordrecht, London, New York. 2011. xii + 386 pp. \$409. ISBN 978-3-642-21022-8.

Interest in the applications of luminescence of the lanthanide ions has been increasing in recent years. The publication of this book is therefore timely and fills the gap in the recent literature on lanthanide luminescence between such works as the encyclopedic multivolume *Handbook on the Physics and Chemistry of Rare Earths*, which covers different, in-depth topics related to the f-elements, and smaller textbook-like volumes on the luminescence and chemistry of the lanthanides and actinides.

There are 14 chapters, authored by well-known researchers in the field. The first gives a streamlined introduction to the photophysical basis of lanthanide ion luminescence. In it, the quantum mechanical treatment of the Hamiltonian for the electrons in the f-orbitals, including spin-orbit coupling and ligand field interactions on the f-electron configuration and their effects on the shape of the absorption and emission bands, is briefly explained. It further details how the latter experimental quantities can be utilized to gather information about the symmetry and structure of the emitting complexes. The theory of f-f as well as 4f-5d and charge-transfer transitions is also covered. Finally, there is a discussion of the experimental determination of emission efficiencies and other related quantities, such as excited-state lifetimes, sensitizing efficiency, solvation of the lanthanide ion, fluorescence resonant-energy transfer, and the use of lanthanide ions as analytical probes. Although other review articles exist that cover these topics in several different combinations and variations, one chapter encompassing all this information is particularly useful, as it presents all the information in a uniform shape, with consistent abbreviations and variables throughout the chapter, making it a very good introduction for the reader new to the area.

Many of the remaining chapters of the book deal with the direct applications of the luminescent lanthanide ions, with a main focus on biomedical and bioanalytical applications. A few others concern the basics of instrumental techniques. Specifically, in Chapter 2, the criteria for rational design of coordination compounds as bioprobes are outlined, with emphasis on linear and macrocyclic chelates. In Chapter 3, different types of nanoparticles as photoluminescent reporters in homogeneous and heterogeneous assays are presented. Both chapters include reviews of the literature up to 2008–2009. Chapter 4 stays with the topic of nanoparticles but focuses on upconversion luminescence. It provides a good introduction to the different synthetic techniques for synthesizing nanoparticles and a discussion on mechanisms of nucleation. Finally, the literature on the use of nanoparticles for biomedical applications, such as photodynamic therapy and bioimaging, as well as nonlife science applications is reviewed. The luminescent coordination

chemistry of the lanthanide ions, introduced in Chapter 2, is continued in Chapter 6, in which the authors review polymetallic assemblies of lanthanide ions, covering the literature up to 2009. A review of the literature up to 2008 of complexes used as oxygen, pH, peroxide, copper, small organic molecules, temperature, or humidity sensors, is given in Chapter 8.

By and large, most chapters cover emission in the visible region of the electromagnetic spectrum, but Chapter 5 focuses on the use of the near-infrared-emitting lanthanide ions and their complexes as luminescent labels and probes in bioanalytical detection and imaging. An additional discussion on new detector and light source technologies in this region of the spectrum is included.

Chapter 7 expands on the introduction in Chapter 1. The luminescence of lanthanide ions mostly in the solid state within solid-state lattices is discussed, along with nonradiative processes and emission due to charge-transfer transitions, defect sites and impurities within the crystal lattice, and emission from divalent lanthanide ions. Other effects such as second harmonic generation, different mechanisms of upconversion, photon avalanche processes, and upconversion in transition metal-lanthanide ion systems are also discussed. Finally, the uses of all these mechanisms in areas such as lighting, quantum cutting, displays, scintillators, and solar energy conversion are reviewed.

Chapters 9–11 deal with instrumentation-related topics. Two of these illustrate the theory and instrumentation of lifetime measurements, which can be done in the time-domain or frequency-domain regime. Most commercially available fluorimeters offer lifetime measurement options with one of these two techniques, and the information contained in these chapters should facilitate decisions for acquiring the instrumentation. It also provides information to set up custom-built systems. Chapter 11 covers the techniques and instrumental makeup for time-resolved microscopy for fluorescence imaging with lanthanide ion probes. Applications of time-resolved fluorescence microscopy in the clinical areas are reviewed in Chapter 12, with a survey of selected papers up to 2007. The topic of sensitized bioassays is further expanded in Chapter 14 with an extensive review of the literature. Chapter 13 covers electrochemiluminescence of the lanthanide ions, with an introduction to the field and discussion of the sensitization and emission mechanisms, followed by a presentation of analytical applications.

In summary, because of the increase of the research community's interest in emitting lanthanide ions and/or their complexes for applications ranging from lighting to imaging and sensing, the publication of this book, which provides extensive information on lanthanide luminescence and associated instrumentation as well as the state-of-the-art research, is timely.

Ana de Bettencourt-Dias

University of Nevada, Reno

10.1021/ja210402p

Published: November 14, 2011