

RARE EARTH NANOTECHNOLOGY

edited by
Timothy T. Y. Tan



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*I humbly dedicate this book to my parents,
Mr Tan Boon Chew and Mdm Lee Ah Sioh,
and sister, Ms Tan Foong Yee,
who have provided the foundation and
compassion on which I have been blessed
to rely and build.*

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Preface

Rare earth elements (REE) are gaining ubiquitous importance in modern technology and have been touted as the “vitamin of chemistry.” They help technologies perform better and have their own unique characteristics. Many high-technology industries depend heavily on these unique elements for the manufacture of permanent magnets and batteries, which are vital to efficient military and green technologies such as wind turbines and hybrid batteries, as well as in smartphones and laptops.

REE are, in fact, not rare, and most of them are fairly abundant in the earth’s crust. What is rare about REE is their supply. China controls 95% of the world’s REE production, not exactly due to geological luck but more due to economic and scientific strategies. In 2011, REE attracted unprecedented news when China announced a 70% cut in its rare earth production, sending shockwaves through the world as it feared a supply crunch. Since then, various plans to establish rare earth production outside China have been in the pipeline, with Australian mining company Lynas having been successfully granted approval to build one of the largest rare earth refineries in Malaysia.

This book was conceived prior to these events, when the exploration, research, and development of rare earth materials in nanotechnology were burgeoning at the start of the millennia, especially in the fields of nanomedicine and nanophosphors. This book, therefore, focuses on the potential applications of rare earth materials in these areas and their state of the art in these applications. The aim of each chapter is to review and highlight the strategies and insights of the research work in the relevant areas, in a hope to establish continued and long-term research efforts of these amazing materials in nanotechnology.

This book consists of six chapters put together in a cohesive and sequential manner, but they can be read as standalone chapters. As the properties of rare earth elements can be found in many textbooks and journal articles, they have not been included in this book. The book begins with highlighting key strategies in

the design and synthesis of various types and forms of rare earth nanomaterials (Chapter 1), followed by Chapter 2, which discusses various approaches to synthesizing rare earth nanomaterials of different morphologies and their surface modification to render them suitable for their intended applications. Rare earth materials have intriguing optical and magnetic properties. In Chapter 3, recent works on the application of rare earth nanoparticles in fluorescence microscopy are highlighted, with a strong focus on upconversion rare earth nanoparticles as they are most suited as imaging probes for biological specimen. In the pursuit of better imaging contrast to achieve more accurate diagnosis, there has been much interest, and success, in the use of rare earth nanoparticles as “proof-of-principle” magnetic resonance imaging contrast agents. Their state of the art is discussed in Chapter 4. Chapter 5 demonstrates the foresight of researchers for bimodal contrast agents in bioimaging technology, of which the optical and magnetic properties of rare earth nanomaterials are simultaneously exploited to achieve more accurate and sensitive imaging in fluorescence and magnetic resonance imaging. The last chapter presents the advances and promises of rare earth nanomaterials as cheaper and more efficient lighting materials in light-emitting diodes, resonating the global need for green lighting technologies.

Rare earth elements will continue to exert their significant impact in modern technologies in the coming decade. Supply–demand will shift toward equilibrium with the discovery of more mines and the construction of new refineries.

Hopefully, this book will provide the readers, be it researchers, engineers, or policymakers, with bountiful ideas and inspirations to effect a new level of nanotechnological revolution using REE, especially in the much-needed energy and healthcare sectors.

Timothy T.Y. Tan