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Timothy P. Hanusa

The Lightest Metals

Science and Technology from Lithium to Calcium

Encyclopedia of Inorganic and Bioinorganic Chemistry

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THE LIGHTEST METALS: Science and Technology from Lithium to Calcium

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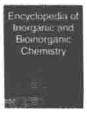

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Series Preface

The success of the *Encyclopedia of Inorganic Chemistry* (EIC), pioneered by Bruce King, the founding Editor in Chief, led to the 2012 integration of articles from the *Handbook of Metalloproteins* to create the newly launched *Encyclopedia of Inorganic and Bioinorganic Chemistry* (EIBC). This has been accompanied by a significant expansion of our Editorial Advisory Board with international representation in all areas of inorganic chemistry. It was under Bruce's successor, Bob Crabtree, that it was recognized that not everyone would necessarily need access to the full extent of EIBC. All EIBC articles are online and are searchable, but we still recognized value in more concise thematic volumes targeted to a specific area of interest. This idea encouraged us to produce a series of EIC (now EIBC) Books, focusing on topics of current interest. These will continue to appear on an approximately annual basis and will feature the leading scholars in their fields, often being guest coedited by one of these leaders. Like the Encyclopedia, we hope that EIBC Books continue to provide both the starting research student and the confirmed research worker a critical distillation of the leading concepts and provide a structured entry into the fields covered.

The EIBC Books are referred to as *spin-on* books, recognizing that all the articles in these thematic volumes are destined to become part of the online content of EIBC, usually forming a new category of articles in the EIBC topical structure. We find that this provides multiple routes to find the latest summaries of current research.

I fully recognize that this latest transformation of EIBC is built on the efforts of my predecessors, Bruce King and Bob Crabtree, my fellow editors, as well as the Wiley personnel, and, most particularly, the numerous authors of EIBC articles. It is the dedication and commitment of all these people that are responsible for the creation and production of this series and the "parent" EIBC.

Robert A. Scott
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October 2015

Volume Preface

We live in a world in which uses for the "lightest metals" are ubiquitous. The seven metals with the lowest atomic number are lithium, beryllium, sodium, magnesium, aluminum, potassium, and calcium, and, apart from lithium and beryllium, are extremely common on earth. Al is the most abundant metal in the earth's crust (over 8% by weight), and the metals Ca, Mg, Na, and K rank 5th through 8th, respectively. Although the metals themselves were not isolated until the early 19th century, their compounds have been associated with the development of civilization ever since clay pottery was first fashioned in the prehistoric past. Their critical roles in biology, building and construction materials, and electronic devices are testaments to the centrality of these metals in modern daily life. Technological advances in the 21st century have only increased their indispensability, and it is the overwhelming importance of new developments with these elements that *The Lightest Metals* was designed to showcase.

A single volume could not hope to do justice to the extensive chemistry of these elements. Therefore *The Lightest Metals* focuses on several areas of central importance, and a broader selection of topics that may be less familiar to readers. The Background section begins with an overview of the metals, a discussion of their natural abundance and historical uses, and moves on to describe issues of their production, strategic status, and sustainability. The Fundamentals section looks at the low oxidation state chemistry of the elements, metal-centered NMR (both in solution and the solid state), and the issue of cation–π interactions, important to both coordination chemistry and biology. Also included is an examination of ion channels and ionophores, and a fresh look at the controversial issue of beryllium toxicology. The Applications section reviews new approaches to organic synthesis and catalysis using arylithium, organocalcium and organoaluminum reagents. Several chapters discuss the current state-of-the-art in lithium-ion batteries, and what enhancements or replacements might be on the horizon. Other chapters examine the high-pressure synthesis of hydrogen storage materials, transparent ceramics, light-element superconductors, and one-dimensional nanostructure-enhanced catalysis, in which the lightest metals quite literally play a supporting role — as critically important bases for catalytically active nanorods made of transition metal compounds. Developments in lithium-based therapy for the treatment of depression, and the role of the lightest metals in solar energy conversion and voltaics complete the survey of recent advances.

One of the goals of *The Lightest Metals* is to correct a common perception, even among inorganic chemists, that the light main group metals are somehow limited by their lack of available d orbitals and by their invariant oxidation states. In fact, the wealth of ways in which the metals and their compounds can serve in synthetic, structural, and mechanistic chemistry is restrained only by the imagination of the reader, an imagination that a perusal of *The Lightest Metals* is designed to stimulate.

Finally, I should note that without the unflagging support of the editorial staff at Wiley, and their expert shepherding of this project from its earliest conception, it could not have been completed; they have my profound thanks.

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