Lithium Batteries

Lithium batteries is an extremely vibrant technological area, which attracts numerous researchers from very different disciplines, such as materials science, electrochemistry, inorganic and organic synthetic chemistry, polymer research, solid state physics, and chemical, mechanical, and electrical engineering, as well as others. Thus, it is always a challenge to cover at least part of the world-wide battery endeavors in a single medium-sized book.

As the reader learns from preface, the editors tried to limit the contents by focusing exclusively on the technology of rechargeable batteries. In an era when, at one extreme, the eyes of the world are on ever smaller and more capable portable electronic devices and, at the other extreme, on long-range and powerful electric vehicles, the editors' decision seems almost obvious. However, even in science, any prediction involving a highly dynamic area is difficult and is often little more than crystal-gazing, so the editors must be congratulated on the bold choice of these specific 16 future-orientated chapters.

Following the traditional layout, the introductory chapters give a short overview of the history of batteries and a brief explanation of the main electrochemical concepts such as the Nernst equation, the electrochemical double layer, and the Butler–Volmer equation. Although these concepts are essential, a proper look into the future would require some extension, for example into the transport and reaction phenomena that occur on different scales—from the atomic dimension to that of the electrode. To cover the aspects that apply to fast-developing automotive applications, engineers would certainly welcome a brief survey of multicell problems as encountered in the design and optimization of modern battery management systems.

After a refreshing overview of the main additives currently used in organic electrolytes (Chapter 3), the book continues with an intriguing chapter on novel electrolytes for high-voltage cathodes. Another approach to cathode stability and, most importantly, to battery safety is the complete encapsulation of cathode particles, as explained in Chapter 5. Technology enthusiasts will probably jump directly to Chapter 6, which gives a clear overview of past and near-future trends in energy and power density, and also of the durability and safety of various battery types. The overview of lithium-ion materials and technologies is rounded off by a discussion of the fluorine-based polyanionic compounds that are seen as the most promising candidates for large-scale battery applications.

The next four chapters, extending over more than 100 pages—almost a third of the book—are devoted entirely to the so-called "lithium–air" batteries (in fact, only oxygen from the air is utilized in the electrochemical reaction). This system clearly stands out as regards the theoretical values of specific capacity and energy density. For example, car manufacturers hope that, when it is mature, the lithium-air technology will allow production of electric cars with a range of more than 500 km. However, as the authors point out, there is a long road to go from the present state-of-the-art laboratory experiments. There are many problems, ranging from the question of the stability of metallic lithium to those of the search for a novel type of separator and of the irreversible nature of the cathodic reaction. However, as indicated, there are many promising directions to be explored, so we are awaiting exciting development of this system in the next couple of years.

The common aspect in the next two or three chapters is the use of ionic liquids. They are seen as serious candidates to replace the conventional electrolytes, not only in various battery systems but also in related devices such as supercapacitors, e.g., in electrochemical double-layer capacitors. In the latter, the beneficial role of an ionic liquid is not only to improve the safety but also to increase the energy density by allowing the use of a wider potential window.

The book ends with two post-lithium systems: the magnesium and sodium batteries. Whereas the former could rival the lithium systems in terms of high energy density—due to the possibility of exchanging two electrons instead of just one—the latter are seen as a (perhaps much) cheaper alternative to the lithium technology.

As a whole, the book gives an important insight into current efforts to further improve lithium and post-lithium batteries. Unavoidably, the limited space in a book of this size can only allow a selection of rather condensed chapters. Thus, some readers will miss recent hot topics such as lithium–sulfur, liquid metal, organic, redox-flow, and many other lithium or post-lithium battery types. Others might prefer a different balance within the existing topics. All will agree, however, that currently this is the most advanced batteries book on the market, written by the best experts in the fields covered. The book may be considered a valuable starting point for anyone who is interested in entering the exciting realm of current and, in particular, future battery technologies.

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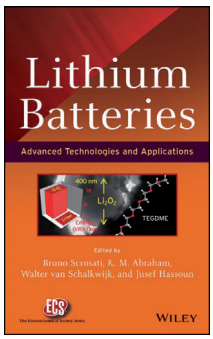

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