Book Review

Book Review of Handbook of Molecular Force Spectroscopy

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BOOK REVIEWS

Handbook of Molecular Force Spectroscopy. Edited by Aleksandr Noy (Lawrence Livermore National Laboratory, Livermore, CA). Springer Science + Business Media, LLC: New York. 2008. xii + 292 pp. $159.00. ISBN 978-0-387-49987-1.

The measurement of forces at the molecular level is an active and exciting area of research that has found application in a diverse range of disciplines, including chemistry, biology, and physics. Much of the progress in this field has been driven by technological advances in instrumentation, particularly the atomic force microscope (AFM), optical tweezers, and surface force apparatus, as well as parallel progress in computational and theoretical methods of data analysis. Force spectroscopy measurements have now grown beyond the proof-of-principle stage, and there is a major drive in the community to apply them at the single-molecule level to increasingly complex systems. As more research groups enter this cutting-edge area of research, a broad overview of core principles of force spectroscopy is of considerable utility and timeliness. Aleksandr Noy, one of the pioneers of force spectroscopy, has done an admirable job of assembling such an overview as well as providing insight into likely new directions of research.

In terms of general organization, this book is divided into 10 different chapters, each written by a well-known investigator in the field of force spectroscopy. Noy himself has coauthored three of the chapters, which seems a bit excessive, although certainly forgivable given his stature in the field. Coverage is admirably balanced between theory and experiment, with approximately half of the chapters primarily aimed at interpreting, modeling, or simulating force spectroscopy data, and the rest on experimental aspects of the discipline. There is some inevitable overlap between chapters, particularly when it comes to describing the underlying theory of the kinetics of bond rupture, although I suspect newcomers to the field will find having this material explained from slightly different points of view beneficial rather than tedious. Overall, the book is well organized, presented, and logically arranged, although I do question the need for color plates (and the result these have on the cover price), as the black-and-white figures were sufficiently clear. Also, the final chapter, "Direct Mapping of Intermolecular Interaction Potentials," by Ashby seems inappropriately titled, since it mainly focuses on electronic and instrumental limitations of the AFM in force measurements. Nevertheless, the material in this section is instructive and certainly a valuable contribution overall.

There are a number of particularly strong points about this book, as well as a few minor shortcomings that should be noted. In terms of the former, Noy, Vezenov, and Lieber's candid discussion of the challenges in measurements using the chemical force microscope, including the importance of tip contact area, mechanical properties of self-assembled monolayers, and solvent effects, was very much appreciated, especially for those of us who have struggled with these issues in our own laboratories. Blanchette et al. present a large and highly detailed compilation of approaches to functionalization of AFM tips, and I anticipate that this will be a much-used resource for veterans and newcomers alike. Finally, the chapter written by Williams on the theory of dynamic force spectroscopy is simply a superb and lucid description of the topic and will also be an invaluable resource to those in the field. As for shortcomings, some of these subjects have previously been reviewed in the scientific literature. For example, much of the material regarding chemical force microscopy has already been covered by Lieber and others. I was somewhat disappointed that there was not more space dedicated to the theory and practice of calibrating AFM cantilevers, as this is a very important topic in force spectroscopy and a lively area of research. Finally, I was surprised that the book did not contain a substantial discussion of the important work carried out on mechanical properties of polysaccharides. This work has had considerable impact in the area and it would have made for a nice addition to this book. Nonetheless, these shortcomings are minor and do not significantly detract from the work as a whole.

In conclusion, Noy's *Handbook of Molecular Force Spectroscopy* is both a timely and useful summary of fundamental aspects of molecular force spectroscopy, and I believe it would make a worthwhile addition to any good scientific library. New research groups that are entering this field would be well advised to study this handbook in detail before venturing into the exciting and challenging world of molecular force spectroscopy.

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Applications of Physical Methods to Inorganic and Bioinorganic Chemistry. Edited by Robert A. W. Scott (University of Georgia) and Charles M. Lukehart (Vanderbilt University, Tennessee). John Wiley & Sons, Ltd.: Chichester. 2007. xvi + 576 pp. $220. ISBN 978-0-470-03217-6.

This book provides comprehensive and yet easily approachable coverage of the wide range of physical methods that researchers use to study inorganic and bioinorganic systems. As stated in the Preface, the book is designed to provide answers to such questions as: " 'what kind of information would this method provide?' or 'what constraints are there on the type of sample that can be examined?' and, more importantly, 'what information will not be available if I employ this method, (i.e., what are its limitations)?' " It covers in 26 chapters all the standard spectroscopic techniques, including electron paramagnetic and nuclear magnetic resonance (several chapters), circular dichroism, magnetic circular dichroism, electronic, vibrational, rotational, photoelectron, electron energy-loss, luminescence, X-ray absorption, perturbed angular correlation of γ-rays, and Mössbauer spectroscopies. This is much more than a book on spectroscopy, however. Several chapters also cover electrochemistry, freeze-quench kinetics, rapid-scan stopped-flow kinetics, metal analysis, electron diffraction, neutron diffraction, X-ray powder diffraction, neutron scattering, and electron scattering. Each chapter was written by a leading expert or set of experts with extensive experience in the topic covered. The authors have avoided focusing too much attention on the

theoretical underpinnings of each method, although there are references to more theoretical coverage.

A unique and especially helpful feature of the book is the "Method Summary", which begins each chapter and addresses the questions raised in the Preface. These summaries also delineate what can and cannot be accomplished with each technique and which systems can be examined. Using the Method Summary, nonexperts can quickly identify the best techniques for their research requirements and gain sensible knowledge about experimental parameters and limitations. Clear examples of how each method is used are also included.

To carry out cutting edge research in inorganic or bioinorganic chemistry, investigators need to employ numerous physical methods and a range of instrumentation to fully characterize the molecules and materials being studied and to analyze their reactions. The comprehensive coverage of this book should make it highly useful for all types of inorganic chemists, whether they are studying inorganic or organometallic systems, synthetic or naturally occurring bioinorganic molecules, or solid-state materials. Establishing the structure and reactivity of all these types of inorganic systems is best accomplished through the use of a number of complementary physical methods. Investigators will find this book to be an outstanding, useful, and practical resource to help them understand the effectiveness of each physical method and thus determine which techniques from the large arsenal of available physical methods will best address their research needs.

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Reviews in Computational Chemistry, Volume 25. Edited by Kenny B. Lipkowitz (Howard University, Washington, D.C.), Thomas R. Cundari (University of North Texas, Denton), and Donald B. Boyd, Editor Emeritus (Indiana University−Purdue University, Indianapolis). J. Wiley & Sons, Inc: Hoboken, NJ. 2007. xxx + 418 pp. $180.00. ISBN978-0-470-17998-7.

The 25th volume of this series once again succeeds as a compilation of influential reviews of recent research advances in the field of computational chemistry. For many of us, the series has held an important place for building an initial body of knowledge in the field and continues to serve as a useful resource for more advanced researchers. As a young undergraduate, hungry to learn more, my discovery of the series in the chemistry school library at the Autonomous University of Mexico was an exciting treasure trove of accessible information. At roughly 50 pages, with approximately 100 references each, the chapters offer enough detail for an accessible introduction to a subfield of theoretical chemistry appropriate for advanced undergraduates and practitioners in other related disciplines, both experimentalists and theoreticians alike.

The quality of the series has remained high over the many volumes, and quite naturally, a number of topics have been revisited from many perspectives. This reprising of key topics is one of the strengths of this series because it provides an important base for those new to the field and also offers researchers additional up-to-date information on the most recent developments. For example, in an inspiring chapter in this series, Cartwright outlines the "Development and Uses of Artificial Intelligence in Chemistry," which complements and expands upon Judson's contribution, "Genetic Algorithms and Their Use in Chemistry," in Vol. 10 (1997) and Peterson's piece, "Artificial Neural Networks and Their Use in Chemistry," in Vol. 16 (2000).

This volume covers a wide variety of topics under the broad definition of computational chemistry and its potential applications. Topics range from Guo's excellent review of "Recursive Solutions to Large Eigenproblems in Molecular Spectroscopy and Reaction Dynamics" to Mosey and Müser's contribution on the "Atomistic Modeling of Friction."

The only drawback of this book is the hefty price tag of $175, which, despite its popularity, is a huge deterrent for individuals who would like to own this valuable text. Instead, it remains confined to libraries and the offices of a few professors. Consequently, I have seen many graduate students and postdoctoral researchers photocopying parts of the book for their own use. If the volumes were more affordable, many more copies of this series would find their place on students' shelves.

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Inorganic Mass Spectrometry: Principles and Applications. By Johanna Sabine Becker (Research Centre Jülich, Germany). John Wiley & Sons, Ltd.: Chichester. 2007. xx + 496 pp. $200. ISBN: 978-0-470-01200-0.

Inorganic mass spectrometry is a powerful analytical technique focused on multielement determination, surface analysis, and measurement of isotopic ratios. There is a real need for a book on this broad topic; a similarly titled work from de Laeter was published in 2001 and did not cover many recent important developments in ICP-MS in particular. Becker has remedied this with an authoritative, comprehensive, and up-to-date account of the field suitable for the experienced researcher and novice alike. The book will equip readers with a sound basic understanding of the principles underlying inorganic mass spectrometry and the applications that are driving the field forward. The book benefits from single authorship in that the transition from one section to another is never jarring. Becker's prose is clear, concise, and precise throughout, and the consistency makes the technical material much easier to read than would otherwise be the case. It would make an excellent foundation for a graduate course on the subject.

An outstanding feature of the book is the abundance of figures, photographs, diagrams, and spectra. The eclectic mixture of styles does not enable easy comparison between one instrument/device/spectrum/technique and the next, but it certainly adds great graphical richness to the text. The figures are further enhanced by the liberal use of color throughout, especially in the sections on instrumentation and tissue analysis.

The book contains many tables offering comparisons that are very useful for browsers looking for the best method to solve their particular analytical problem. If anything, they could have been given more prominence throughout—the addition of expert commentary and a frank assessment of the relative standing and impact of the various entries would have made such tables even more valuable. By specifically naming many of the various commercial instruments currently available and by providing manufacturer schematics and comparing their relative merits,

the author has boosted the immediate impact of the book. However, given the fast-moving rate of technological advancement in the field of mass spectrometry, much of this information is likely to become outdated quickly. The book contains over 1800 references and is scrupulously up-to-date, with the majority of the cited references published post-2000.

The book concludes with over 200 pages covering applications in materials science, the environment, pollution studies, biology and medicine, food analysis, geology and geochemistry, cosmochemistry, radionuclide determination, and forensic analysis. This overview would benefit researchers in all of these fields, and practitioners with any suspicion that modern inorganic mass spectrometry may provide them with some useful answers would be well advised to secure a copy of this text.

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Six-Membered Transition States in Organic Synthesis. By Jaemoon Yang (Montana State University). John Wiley & Sons, Inc.: Hoboken, NJ. 2008. x + 210 pp. $125.00. ISBN978-0-470-17883-6.

In this book, Yang tackles a topic central to the stereochemical outcome of a variety of organic reactions, including sigmatropic rearrangements, the aldol reaction, and carbonyl reductions. At the heart of the exploration is the notion that a six-membered transition state controls selectivity in these transformations, a concept first introduced by Zimmerman and Traxler 50 years ago. This contribution has had an enormous impact on the stereochemical analysis of reactions, as illustrated by the fact that this transition state bears their names.

The topic is covered in four chapters, the first dealing with [3,3] sigmatropic rearrangements. The author takes a composite approach to the discussion, providing both experimental evidence and the original stereochemical model that was advanced by the developers of the reaction, along with subsequent computational studies. The meld works in ways that each alone could not. For example, the author includes the classic Doering/Roth experiment in connection with the Cope rearrangement and follows it up with Houk's computational support. The chapter also includes several examples of the reaction in the context of complex molecule synthesis.

The aldol is addressed in the second chapter, which covers the common auxiliary-controlled asymmetric aldol reactions. The chapter closes with a discussion of the proline-catalyzed reaction. As with the first chapter, extensive experimental evidence for the models is aided by computational support when available. The next chapter covers allylmetal additions to carbonyls. The inclusion of 21st century examples, including Denmark's phosphoramide-catalyzed allylations, is noteworthy. Finally, the author tackles stereoselective reductions and includes reagent and substrate-controlled examples in the last chapter. Meerwein−Ponndorf−Verley-type reductions are noteworthy for their absence in this chapter, with the exception of alkyl borane-based reductions such as Ipc_2BCl. The omission of this class of reactions is an exception to the rule, as the author's coverage of the topics is generally very thorough. Again, as in previous chapters, the author includes many examples from total synthesis of complex molecules.

In many places, the author provides considerable experimental detail that is of interest to practitioners in the field. These details, while pedestrian and occasionally tedious, are required for successfully executing the procedure and are of interest to the expert reader. On the whole, this monograph is a perfect treatise for junior graduate students seeking an in-depth introduction to issues of stereochemical control in a variety of bond-forming reactions. Coverage is comprehensive in concept but not exhaustive with examples. It is an interesting, well-written, and carefully researched book, full of useful details for practitioners and students of organic chemistry.

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Amino Group Chemistry: From Synthesis to the Life Sciences. Edited by Alfredo Ricci (Università di Bologna, Italy). Wiley-VCH Verlag GmbH & Co. KGaA: Weinheim. 2008. xiv +394 pp. $200. ISBN 978-3-527-31741-7.

This multiauthor compilation covers a great deal of ground in the chemistry of organic amines. The title should not mislead the reader into thinking that the book delves too far into biology. The heart of this work is organic synthesis, although the frequent occurrence of nitrogen in bioactive compounds makes this volume very relevant to biological science. Its utility to the chemical community rests on its accessible presentation of a vast collection of nitrogen chemistry. The nine chapters tend to be comprehensive summaries rather than expositions of the very latest research in a specific area; thus, not all of the extensive—but not excessive—references are recent. This historical perspective is welcome, as exemplified by the final chapter covering the Ullman and Buchwald−Hartwig aminations. The subject areas are quite diverse, including electrophilic amination, catalytic asymmetric Mannich reactions, nitroalkene building blocks, and amino sugars (two chapters). In some cases, brief experimental descriptions are provided. The chapters are of uniformly high quality, and the volume is beautifully presented. There is also an extensive subject index. Readers from any of the fields covered could profit from browsing this book, enabling concepts from one subject to cross-fertilize another.

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Light, Water, Hydrogen: The Solar Generation of Hydrogen by Water Photoelectrolysis. By Craig A. Grimes, Oomman K. Varghese, and Sudhir Ranjan (Pennsylvania State University, University Park). Springer Science + Business Media: New York. 2008. xxiii + 546 pp. $129. ISBN 978-0-387-33198-0.

The "Holy Grail" of artificial photosynthesis, particularly for hydrogen production, is often traced to the Fujishima−Honda (FH) paper that appeared in *Nature* in 1972, although work like this dates back almost 100 years, at least to Ciamcian's 1912 paper in *Science*. For the past 36 years, there have been active investigations directed toward discovering materials that can

produce useful systems with the required efficiency, cost, and stability. This book deals with this field, largely from the point-of-view of solid-state synthesis and engineering. Its main thesis, I believe, is that the best—but not yet adequate—systems so far for this purpose involve TiO_2 nanotubes, which are the authors' area of interest; a long Chapter 5 deals with these aspects.

The book begins with a rather brief discussion of energy, climate change, renewables, and the hydrogen economy, although at least four pages are devoted to listing, in detail, aspects about the U.S. military presence in the Middle East. Chapter 2 is an overview of various approaches to water splitting to hydrogen, such as electrolysis or thermochemical processes. The real meat of the book begins in Chapter 3 on the general principles of photoelectrolysis and photoelectrochemistry (PEC), followed by Chapter 4 on oxide semiconductors and Chapter 5 on nanotubes. The remaining chapters deal with suspended nanoparticle systems, e.g., photocatalysis, and nonoxide semiconductors and include a brief discussion of solid-state photovoltaic solar cells and their use in powering water electrolysis.

The book is useful for getting brief descriptions of the huge literature on oxide semiconductors prepared in different ways and their behavior. It is less useful for understanding the details of PEC or the techniques of characterizing materials and electrochemical cells. Aspects of the review are not particularly critical. For example, an important recent area of interest in TiO_2 PEC involves the effect of doping with C and N (so-called "anion doping"); however, the discussion in the book does little to elucidate the issues or explain the results and efficiencies that have been reported with these kinds of materials. It is also somewhat repetitious, perhaps because it is a multiauthor work, so that, for example, the FH-experiment is described repeatedly, with little cross-referencing, sometimes without explaining that hydrogen and oxygen evolution require an internal bias by using different pH solutions at the anode and cathode. Similarly the popular dye-sensitized solar cells are only considered briefly.

If one wants a detailed picture of PEC, experimental techniques, and applications, I prefer the recent volume edited by Stuart Licht in the *Encyclopedia of Electrochemistry*. However if oxide materials, and especially TiO_2 nanostructures, are of major interest, this book will be useful in traversing the massive literature in this field.

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