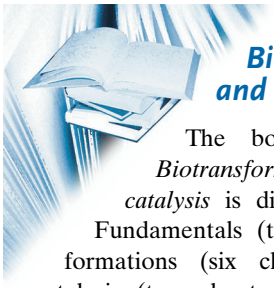


Ionic Liquids in Biotransformations and Organocatalysis

The book *Ionic Liquids in Biotransformations and Organocatalysis* is divided into three parts: Fundamentals (two chapters), Biotransformations (six chapters), and Organocatalysis (two chapters). The first, introductory, chapter discusses the principles of ionic liquids and the history of their development. In a major section, the "green" credentials of ionic liquids are critically examined. Chapter 2 discusses the interactions between ionic liquids, water, and proteins. A quite impressive volume of literature is analyzed here, including issues with regard to protein renaturation and protein extraction. The authors discuss the literature mainly in terms of the Hofmeister characteristics of the constituent ions, an approach that has failed to convince me. I hasten to add that there is, as yet, no sound theory of enzyme behavior in ionic liquids (or indeed in molecular solvents). Chapter 2 is particularly valuable for summarizing nearly all that is known about the effects of ionic liquids on proteins. This chapter concludes with a discussion of the proper selection of ionic liquids for biocatalysis, which will be of assistance to newcomers in the field.

Part II, on biotransformations, opens with a historical overview of ionic liquids in biocatalysis, which also discusses the motivation for using ionic liquids. Unfortunately, the discussion soon drifts off into a summing-up of reaction methodologies, and could have been structured more clearly. Chapter 4 presents an overview of process engineering with non-conventional solvents. Both monophase and multiphase processes are discussed, and the review also covers supercritical and fluorous media. This chapter is highly valuable and is essential to the book, because the exceptional solvent behavior of ionic liquids is, in my view, the key to their (economically) successful application.

Chapter 5 is devoted to the use of ionic liquids as solvents or co-solvents with hydrolytic enzymes. It opens with an overview of hydrolase activity and stability in connection with the characteristic properties of the constituent ions in the ionic liquids. The discussion extends into enzyme modification and immobilization, as well as reaction engineering. The review of actual biotransformations is focused on kinetic resolution (traditional and dynamic) and on resolving solvent incompatibilities (esterification of saccharides, including cellulose), and concludes with a brief discussion of glycosidase catalysis.

The use of ionic liquids as (co)solvents with non-hydrolytic enzymes (oxidoreductases, aldolases, and oxynitrilases) is reviewed separately in Chapter 6. These enzymes differ widely with regard to structure, mechanism, and general behavior, so that an integrated discussion is almost impossible. However, the chapter is useful as a review of the scattered and sometimes fragmented literature data.

Whole-cell biotransformations in ionic liquids are the subject of Chapter 7. The chapter reviews the state of the art, with appropriate emphasis on enantioselective whole-cell reductions. Important issues, such as biocompatibility, accumulation in the cell, and effects on cell membranes, are included in the discussion, and a comparison with molecular solvents is presented. In this chapter, attention has also been given to ecotoxicity issues, which are barely mentioned elsewhere in the book.

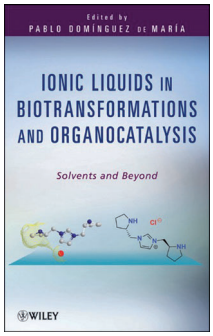
Non-solvent biocatalytic applications of ionic liquids are reviewed in Chapter 8. The overview includes the use of ionic liquids for coating enzymes, the anchoring of reactants to ionic liquids, and procedures that combine membranes and ionic liquids. The final section is on the use of ionic liquids in bioelectrochemistry.

Part III, on ionic liquids in organocatalysis, is barely connected with the preceding parts, although some of the introduction in Chapters 1 and 2 will be useful. Chapter 9 is on ionic liquids as (co)solvents and (co)catalysts. In the largest section, the recent results (mainly from three research groups) are reviewed according to the different reaction types: aldol additions, Mannich reactions, etc., but unfortunately with little cross-referencing or any other effort to present an integrated discussion.

In Chapter 10, non-solvent applications of ionic liquids in organocatalysis are reviewed. These encompass applications of supported ionic liquid phases, of organocatalysts anchored to ionic liquids, and the use of free or carrier-fixed ionic liquid organocatalysts. It seems to me that such task-specific ionic liquids will be the key to industrially viable organocatalytic transformations.

Ionic liquids have many aspects, as the editor notes in the preface. Ionic liquids, moreover, behave in highly unconventional ways, not at all like molecular solvents, and do not readily fit into our traditional ways of thinking about solvents. Thus, the reviewers faced a formidable task.

How well did they succeed? There is some room for criticism. The combination of biocatalysis and organocatalysis in one book does not strike me as a happy one, as there is little overlap of the subjects. The question of what advantages ionic liquids offer for biocatalysis does not come across very well, except in Chapter 4. The notion that ionic liquids, if cleverly applied, will cause a revolution in reaction technology and downstream processing is only weakly argued, and a skeptic who views ionic



Ionic Liquids in Biotransformations and Organocatalysis
Solvents and Beyond. Edited by Pablo Domínguez de María. John Wiley & Sons, Hoboken, 2012. 435 pp., hardcover, € 120.00.—ISBN 978-0470569047

liquids as intriguing solutions looking for problems will probably not be converted. Through no fault of the contributors, the book inevitably reflects the literature with regard to the types of ionic liquids that are reviewed and, regrettably, the emphasis is—with some notable exceptions—still on combinations of alkylimidazolium cations and fluorinated anions.

Taking it all in all, I recommend this timely and, within limits, well organized book as a fairly complete overview of the literature up to 2008–2009, plus a few more recent publications. It will be an essential source for newcomers to the field, and a very useful one for the initiated.

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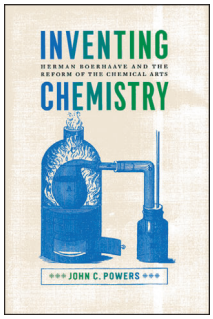

Inventing Chemistry
Herman Boerhaave and the Reform of the Chemical Arts. By John C. Powers. University of Chicago Press, Chicago, 2012. 272 pp., hardcover, $ 40.00.—ISBN 978-0226677606

Inventing Chemistry

Herman Boerhaave (1668–1738), a Dutch chemistry professor at the medical school of Leiden University, was very famous during his life, and his writings reached a broad readership. His work formed a cornerstone for chemical knowledge in the eighteenth century. His major publication in 1732, *Elementa chemiae*, was a bestseller for decades. In the first half of the 18th century, Boerhaave was seen as one of the most famous scientists of Europe, and even in 1770 the Prussian King Frederick the Great (Berlin) declared that all medical doctors had to follow the practice of Boerhaave. His memory continues in Leiden, being celebrated in the National Science Museum (Boerhaave) named after him, in his statue at a prominent location in the town, in various post-PhD courses given by the present Medical Faculty, and in other ways.

It is not surprising that such a great man has inspired many biographers over many years. *So why should we read a new one? And why should chemists read especially this one?* The answer to the first question is that the author has managed to include many new findings, based on his access to previously inaccessible Boerhaave manuscripts. These had been taken by Boerhaave's nephew to Russia, where the scientist had worked as physician in service to Peter the Great, and they are still kept in the military academy in St. Petersburg. The answer to the second question is that the well-known historian John C. Powers has done a really great job, especially for chemists. In *Inventing Chemistry*, he focuses strongly on Boerhaave's educational philosophy and his scientific thinking in the early days of chemistry. He describes the transition from a theology student to a student of medicine, and from there to a pioneering chemist, in a way that combines excellence with a good feeling for the motivation of Boerhaave. Also the story of how Boerhaave took his medical degree in another University (Harderwijk) to save time is described elegantly, as is his turning down of a chair offer from Groningen in 1703 on the promise that he would be given a chair in Leiden as soon as one should become available. (At that time, five chairs was the absolute maximum number in any medical faculty; he might have had to wait until 1709!). This unusual promise was made because he attracted so many foreign students (and therefore income for the university!). So in 1709 he was appointed to the chair of botany, and a few years later chemistry teaching was also added to that chair.

Powers starts this biography at the time when Boerhaave was a student in Leiden, then goes on to describe his beginning a career in medicine and his study of the didactics of chemistry in Leiden, which he started in his spare time alongside his medical practical work. In the next chapter, he continues with the institutes of chemistry and with the role of chemistry in the Medical Faculty. It was Boerhaave who turned the Faculty into a center of excellence in the early 18th century, attracting students from all over Europe. If you wanted to learn state-of-the-art medicine, Leiden was the place to be. Of all medical teachers, Boerhaave taught the most comprehensive medical courses, based on a clever amalgamation of the scientifically relevant ideas of others. Boerhaave restructured and reinterpreted several existing practices from a variety of chemical traditions, including even alchemy. A Dutch physician who taught his students by taking them to the sickbed—this was unprecedented! He is therefore also seen as the founder of clinical teaching. He is also considered as the inventor or architect of a new "philosophical" chemistry, revolutionizing the conceptual foundations of chemistry.

His famous statement on the relevance of chemistry for medicine, which is valid even today, reads: In Physics one need not despair when guided by Chemistry, in Medicine all good things are expected to come from it. ("*In Physicis nil desperandum est disciplina chimica duce; omnia bona ab hac speranda in Medicis.*")

With two great chapters on philosophical chemistry and the transition from alchemy to chemistry, Powers shows clearly how well he has understood the way of thinking of Boerhaave. He describes how Boerhaave found the argument and precepts for his new chemistry, and how this experimental approach became the central part of

