Reactions at Solid Surfaces

Substance conversion at interfaces is an interesting topic that is always associated with a mysterious aura. Gluing a hook to the side of a cupboard, watching a sausage turning brown on the barbecue, and noticing-with sorrow-the corrosion of a car's frame are omnipresent and easily observable examples in everyday life. In contrast, the complex processes that take place at the surface of a solid-state catalyst and accelerate a chemical reaction without changing the catalyst itself can hardly be observed directly. These hidden processes, which sometimes appear to be "magical", form one of the major bases of modern industrial societies. Being able to manage and control them means having the key to creating precious materials in chemical industry. One of the most important and best known examples is the Haber–Bosch process, in which a gas mixture consisting of nitrogen and hydrogen molecules is converted into ammonia by reactions taking place at the inner surface of an iron pipe. Densely populated and highly industrialized countries would not be able to supply their populations with sufficient food without the nitrogen-containing fertilizers produced from this ammonia. In fact, this product of a chemical reaction catalyzed by the surface of a solid is today nearly as valuable as the gold that the alchemists, at the beginning of the modern age, hoped to generate from common materials by using the "philosopher's stone". In this respect, heterogeneous catalysis always reminds us of the origins of chemistry.

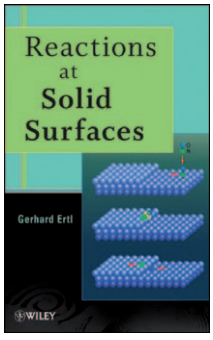
Professor Gerhard Ertl of the Fritz Haber Institute in Berlin is certainly the scientist who is best qualified on both the national and international levels for giving an introduction to heterogeneous catalysis. The book *Reactions at Solid Surfaces* offers a well-thought-out and excellently compiled introduction to chemical aspects of surface science. The author is one of the very few scientists active in this field who can set up such a guided tour through surface science with only the products of his own "garden". He largely restricts his account to milestones of his own scientific career, thus allowing the reader, at the same time, to follow the development of the "surface science approach to understanding heterogeneous catalysis" that he established, and for which he was awarded the Nobel Prize in Chemistry in 2007.

The book is based on a series of eight presentations made by Ertl during his stay at Cornell University in early 2007. The introductory chapter, written for readers who have no specialized background knowledge, presents simple but fundamental principles, aiding and guiding a novice's first steps into the world of surface reactions. The material presented enables the reader to gain a basic understanding of surface science and in particular of chemical processes at surfaces, and also provides a basis for the following seven chapters. In the next three chapters, the streamlined discussion of surface structures, the dynamics of gas/surface interactions, and surface chemistry is limited to essential aspects, but proceeds on a somewhat higher level. The non-expert reader will have to invest substantially more effort and time to profit from this material. Here, the more advanced discussion of aspects of surface physics and surface chemistry is based on a series of case studies by the author's working group, which date back to various periods of his career. Frequently, these case studies also cover kinetic aspects of chemical conversions. This is an interesting point, since they typically differ significantly from the kinetics of chemical processes occurring in the gas phase or in solution. Because of the advanced level, non-expert readers will have to consult the original publications and articles indicated in the text. In addition, in many cases they will need to ask for comments by specialists.

The next chapters present a more general introduction to the basic principles of heterogeneous catalysis (Chapter 5), followed by a somewhat more condensed discussion of mechanistic aspects. Chapters 7 and 8 cover nonlinear chemical conversions at surfaces. This interesting and very complex field of surface chemistry also includes the so-called oscillating reactions, an area of research in which the author has taken a special interest.

The numerous examples given in the different chapters of the book illustrate the use of conventional and well-established experimental techniques in surface science. Using these techniques, a "database" has been generated in the past few decades. Today, this established database is the basis of the current blossoming of the field of surface science. However, recent developments are being driven by a stream of new information provided by modern experimental techniques developed during the past few years. The scientific scope of the book also includes these more recent developments (e.g., the use of nonlinear optical methods for in situ monitoring of chemical reactions). The numerous figures are mostly taken from original papers and they complement the running text very well. The compilation of colored versions of some of the figures in the middle of the book is very helpful.

This monograph is certainly no schoolbook that could be used for an in-depth self-study of surface science. Readers without specialized knowledge in the field of interface chemistry or students looking for a good introduction to this interesting topic will find Chapters 1 and 5 especially useful. The clear



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presentation of basic principles of heterogeneous catalysis given here will motivate the interested reader to study this topic more extensively and in more detail. However, the material presented in the rest of the chapters will not alone be sufficient for that; instruction by a teacher having the relevant background will be required, together with information from more detailed literature.

The theoretical description and analysis of surface physics and surface chemistry processes has made essential and decisive contributions to our present understanding of interface phenomena. These aspects may have been somewhat neglected by the author. However, at many places the text refers to specialized literature dealing with theoretical and computational aspects, so that the interested reader is in a good position to acquire the theoretical background needed for a complete understanding of this field of work.

This excellent compilation of some of the most important milestones in the development of surface science, from the search for the philosopher's stone to a modern science that is relevant to many other sciences, and in particular to materials science, can certainly be recommended for reading. Even readers who are not specialized in this field will soon become aware of the fact that surface science, and in particular surface-induced chemical reactions, are far from being completely understood. There are still a number of questions that need to be tackled. This field of science is presently developing vigorously and will certainly produce more surprises in the future.

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