VOLUME III: APPLICATIONS OF SOL-GEL TECHNOLOGY

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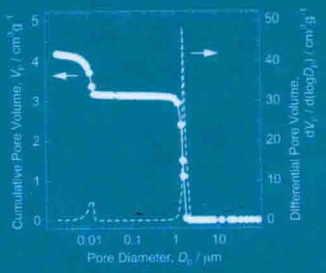

HANDBOOK OF SOL-GEL SCIENCE AND TECHNOLOGY

Processing Characterization and Applications

EDITOR Sumio Sakka

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HANDBOOK of SOL–GEL SCIENCE and TECHNOLOGY

Processing, Characterization and Applications

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VOLUME III

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Preface to the Handbook (Sol–Gel Science and Technology)

This three-volume Handbook "Sol–Gel Science and Technology" was planned with the purpose of providing those who are interested in processing, characterization and application of materials with comprehensive knowledge on sol–gel science and technology.

Around 1970, three different groups in the field of inorganic materials published research results on preparation of glass and ceramics via solutions or sol–gel route. H. Dislich prepared a pyrex-type borosilicate glass lens by heating a compact of metal alkoxide derived powder at temperatures as low as 650°C. R. Roy prepared a millimeter-size small piece of silica glass via sol–gel route at temperatures around 1000°C. Mazdiyasni et al. showed that well-sintered, dense ferroelectric ceramics can be obtained at temperatures as low as 900°C, when sol–gel powders prepared from solutions of metal alkoxides are employed for sintering.

Those works stimulated people's interest in sol–gel preparation of inorganic materials, such as glasses and ceramics. Materials scientists and engineers paid attention to the possibility of this method in giving shaped materials directly from a solution without passing through the powder processing and the fact that the maximum temperature required for processing is very low compared with conventional technology for preparing glasses and ceramics. Thus, many efforts have been made in preparing bulk bodies, coating films, membranes, fibers and particles, and many commercial products were born.

The significant characteristics unique to the sol–gel method became evident, when organic-inorganic hybrid materials were prepared by H. Schmidt and silica materials containing functional organic molecules were prepared by Avnir in early 1980's. Such materials are produced at low temperatures near room temperature, where no decomposition of organic matter takes place. Low temperature synthesis and preparation of materials is the world of chemists. Therefore, the sol–gel method was propagated to the wide area including not only glasses and ceramics, but also organic and biomaterials.

In 1990, an excellent book entitled "Sol–Gel Science" was written by Brinker and Scherer, obtaining a very high reputation. However, the remarkable scientific and technological development and broadening in the sol–gel field, together with an enormous increase in sol–gel population, appeared to demand publication of a new, comprehensive Handbook on sol–gel science and technology.

Thus, it was planned to publish the present Handbook, which consists of the following three volumes:

Volume 1 Sol–Gel Processing
Volume editor: Prof. Hiromitsu Kozuka
Volume 2 Characterization and Properties of Sol–Gel Materials and Products
Volume editor: Prof. Rui M. Almeida
Volume 3 Applications of Sol–Gel Technology
Volume editor: Prof. Sumio Sakka

Volume 1 compiles the articles describing various aspects of sol–gel processing. Considering that the sol–gel method is a method for preparing materials, the knowledge on sol–gel processing is of primary importance to all those who are interested in sol–gel science and

technology. Articles describing processing of some particular property as well as general basics for sol–gel processing are collected.

Volume 2 consists of the articles dealing with characterization and properties of sol–gel materials and products. Since materials exhibit their functional properties based on their microstructure, characterization of the structure is very important. We can produce useful materials only when processing-characterization-property relationships are worked out. This indicates the importance of the articles collected in Volume 2.

The title of Volume 3 is "Applications of Sol–Gel Technology". The sol–gel technology is one of the methods for producing materials and so there are many other competitive methods, whenever a particular material is planned to be produced. Therefore, for the development of this excellent technology, it is important to know the sol–gel science and technology in producing new materials as well as already achieved applications. This is the purpose of Volume 3.

Sol–gel technology is a versatile technology, making it possible to produce a wide variety of materials and to provide existing materials with novel properties. I hope this three-volume Handbook will serve as an indispensable reference book for researchers, engineers, manufacturers and students working in the field of materials.

Finally, I would like to express my sincere thanks to all the authors of the articles included in the Handbook for their efforts in writing excellent articles by spending their precious time. As general editor I extend my thanks to Prof. H. Kozuka and Prof. R. Almeida for their difficult work of editing each Volume. I have to confess that this Handbook would not have been realized without enthusiastic encouragement of Mr. Gregory Franklin, senior editor at Kluwer Academic Publishers.

Sumio Sakka

Preface to Volume 3 ("Applications of Sol–Gel Science and Technology")

Volume 3 entitled "Applications of Sol-Gel Technology" is one of the three volumes of the Handbook "Sol–Gel Science and Technology". It consists of 36 chapters. As the title of the volume shows, each chapter of Volume 3 concerns a group of materials which are produced by applying sol–gel technology.

Sol–gel technology is a versatile technology, that is, this technology is employed to produce a wide variety of materials, such as materials with photonic–, electronic–, mehanical–, chemical–, biological–, and biomedical functions. Articles in Volume 3 cover these functions. In this Volume, materials of various shapes, such as bulk, fiber, coating film, membrane and particle are described. Although the number of the articles for coatings is the largest, it should be noted that other shapes are also very important.

There are three categories in the application of sol–gel technology. In the works belonging to the first category, sol–gel technology is employed as an improved processing method for producing existing materials. A good example is the fabrication of high purity silica shape. The second category includes the application of sol–gel technology to provide existing materials with novel properties. A good example is sol–gel coating of conventional substrates. The third category includes applications to produce unique novel materials which are fabricated only by sol–gel technology. Examples of the articles belonging to this category are found in works on the fabrication of organic-inorganic hybrid materials. Applications belonging to all these categories are found in Volume 3.

Sol–gel method is one of the methods for producing important materials. For some materials there are many competitive methods. Therefore, the use or application of the sol–gel method for preparation of particular materials indicates that sol–gel method is more appropriate than other methods for producing those materials. Actually, some of the articles in the Volume deal with the materials which are already commercialized. It is expected that other materials will be commercialized in near future. The increase in commercial products is very important for the progress of the area of sol–gel science and technology. I believe that it will raise the status of the sol–gel method and in turn the sol–gel science and technology will attract the people who are working in the area of materials.

It is impossible to cover all the applications by the articles collected in Volume 3. Chapter 1 of Volume 3 entitled "Outlines of applications of sol–gel method" will be helpful for obtaining the concept of the whole applications.

I hope that Volume 3 will serve as a guide for those interested in sol–gel science and technology to develop new sol–gel derived materials and products.

I would like to thank the authors of the articles in Volume 3 for their great contribution to the Handbook.

Sumio Sakka

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