Science of Ceramic Chemical Processing

L. L. Hench and D. R. Ulrich (Eds.)
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Chemical-based processing of ceramics, glasses and composites has become one of the most actively pursued and rapidly evolving areas of research in materials science and engineering. The objective of this intense activity is to develop a new generation of high-performance materials.

The present volume is based on the Proceedings of the Second International Conference on Ultrastructure Processing of Ceramics, Glasses and Composites held from 25 February to 1 March, 1985, in Palm Coast, Florida. It comprises sixty papers and is divided into six parts devoted to sol–gel science, applications of sol–gel processing, materials from organometallic precursors, ultrastructure in macromolecular materials, micromorphology science and quantum chemistry. Three of the papers are based on Keynote lectures delivered at the Conference by the distinguished scientists Ralph K. Iler, Paul J. Flory and Per. Olov Löwden, the titles of their contributions being, respectively, 'Inorganic Colloids for Forming Ultrastructures', Network Theory and Gelation', and 'New Directions in Quantum Chemical Calculations – Particularly as to New Materials'.

Part 1 consists of 19 papers on sol–gel science and includes such topics as the sol-to-gel and gel-to-glass conversions, hydrolysis and polymerization mechanisms and kinetics, rheological studies, structure and physical and chemical properties of gels, drying of gels and sintering studies of silica aerogels. Part 2 contains 16 papers on various applications of the sol–gel process including the production of glass and ceramic thin films, fibres, monoliths, powders, substrate materials, disphasic gels and glass and ceramic matrix composites. In Part 3 there are 8 papers on various aspects of the chemistry of organometallic precursors to such important ceramics as silicon carbide and silicon nitride. Among the topics discussed are crosslinking and pyrolysis of silane precursors for silicon carbide, a novel polymeric organosilazane precursor to Si_3N_4/SiC ceramics, electrochemical and sonochemical routes to organosilane precursors and new routes to cyclic spirosiloxanes. Part 4 is devoted to macromolecular materials and contains six articles, which include such topics as conducting polymers, polymer thin films, ordered polymers and molecular composites and particle/polymer suspensions. Part 5 is mainly concerned with colloidal ceramic systems. There are ten papers discussing, for example, synthesis and processing of fine ceramic powders (oxides and non-oxides), structures of colloidal solids, rheological science in ceramic processing and the influence of particle arrangement on sintering. The book concludes with a short section on quantum chemistry (Part 6).

The publication of this most useful volume is timely in view of the considerable efforts currently being made to apply the various traditional branches of chemistry, both separately and in combination, to the development of new processing methods for ceramic materials. This book, which is a companion to 'Ultrastructure Processing of Ceramics, Glasses and Composites' (Wiley, 1984), will be of particular interest to research workers in the field of chemical processing of materials. It will remain a valuable compilation of information for years to come.

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Synthetic Polymeric Membranes: A Structural Perspective

R. E. Kesting
2nd Edn, Wiley-Interscience, New York, 1985, xi + 348 pages, US$80.50, £55.15, ISBN 0-471-80717-6

The first edition of this book, published in 1971, remained unique for fifteen years as the only textbook devoted wholly to the preparation and description of polymeric membranes. Much progress has been made since 1971 and this new edition is essentially a new book. It has no competitor and is essential reading for anyone concerned with developing membranes for separation processes. Despite, perhaps because, of this monopoly position it should not escape critical assessment.

The immense complexity of the molecular processes, governed by thermodynamics and kinetics, that occur during the formation of a polymer membrane has limited the level of scientific understanding achieved so far, while a bewildering mass of experimental observations has accumulated on the properties of membranes formed from multicomponent systems. As a result, any attempt to reduce this information to a coherent text is bound to depend as much on art and informed speculation as on established scientific principles. Dr Kesting is better able than other authors to suggest explanations for groups of empirical facts which seem to work, even in a limited predictive sense, although they would be hard to defend in terms of established polymer physical chemistry.

The book opens with a historical review, fuller than in most books on membrane science, and a short market and literature survey on membrane processes. Two chapters follow, which deal briefly with the main uses of membranes in separations, sensors, batteries and medicine. While a few theories are mentioned the approach is mainly descriptive.

The next two chapters deal with polymer physical chemistry, shaped for dealing with membranes. The first of these deals with the structures of polymer molecules. It is relatively conventional and covers a lot of ground in a single section, 4.1, which would benefit from subdivision. The same applies to 4.2, which deals with particular membrane polymers, common and uncommon. This chapter also contains, rather incongruously, a section on the structure of liquid water and its interaction with polymers.

The chapter on polymer solutions is remarkable for its concentration on polymer–solvent interactions and complete omission of configurational entropy. Any reader should approach this chapter only after studying the basic texts of Flory and others. However, it contains a wealth of information on specific solvent systems, and how and why they have been developed, which could not be found from any other source, except perhaps by months of study of patent literature.

The second half of the book deals in five chapters with particular classes of membranes, categorized primarily by methods of preparation. It is probably reasonable to assume that the reader of such a specialized text will be already well versed in the basic principles of membrane structure and what types are preferred for each process. A reader lacking that knowledge would find these chapters hard to follow. The chapter on dense membranes is almost wholly concerned with polymer crystallization and what influences it. The treatment of phase inversion membranes shows, as in the first edition, Dr Kesting's remarkable ability to see the wood for the trees in this complicated topic, which is so burdened with factual information. His account gives one a very good feeling for what is going on. It makes no concessions to theory, for example spinodal decomposition is mentioned, but no attempt is made to deal with it, perhaps because the author feels that molecular kinetics