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Book review

CHEMISTRY OF ZEOLITES AND RELATED POROUS MATERIALS: SYNTHESIS AND STRUCTURE

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The porous materials, also called molecular sieves, cover microporous, mesoporous and macroporous domains depending on their pore dimensions. Since the discovery of microporous zeolites, the development of advanced porous materials having channels of tunable dimensions at the atomic, molecular and nanometer scale has become a fast-growing interdisciplinary field. This has resulted in materials with improved or new properties, which broadened their application range beyond the traditional use as catalysts and adsorbents. Hence, zeolites and related porous materials may find applications in modern areas ranging from microelectronics and molecular device manufacturing to medical diagnosis.

In this larger context, the book *Chemistry of Zeolites and Related Porous Materials: Synthesis and Structure* focuses on the synthetic and structural chemistry of molecular sieves such as zeolites and zeolite-like microporous materials, mesoporous materials as well as hybrid solids of host-guest-type. It introduces and presents in detail all the relevant aspects of the synthetic and structural chemistry of these materials, including as well two cutting-edge research issues, molecular engineering and host-guest advanced materials respectively.

Whereas this work is addressed mainly to researchers acting in the field of chemistry, material science and chemical industry (for catalysis), the present book aims at making the topic of chemistry of porous materials accessible to advanced undergraduate or postgraduate students being involved in research projects in chemistry, physics, biology or medicine.

The book *Chemistry of Zeolites and Related Porous Materials: Synthesis and Structure* has 679 pages and is organized into nine chapters including bibliographical references, a part containing proposed further readings as well as an index.

The introductory chapter begins with a timeline of the most important events in the history of porous materials. This first part covers the evolution of research from natural zeolites to synthesized ones, from low-silica zeolities to high-silica zeolites, from aluminosilicate molecular sieves to aluminophosphate-based ones, from extra-large microporous materials to meso- and macroporous materials and from inorganic porous frameworks to hybrid materials of MOF-type.

In the second part of this chapter, the main applications and prospects of porous materials are noticed, encompassing the traditional fields of application in catalysis, adsorption and separation as well as the modern ones such as fine chemistry, environment, biology, medicine, energy, electronics etc. A discussion regarding the development from synthesis chemistry to molecular engineering of porous materials is also included in the final part of this chapter, emphasis being put on the necessity to design porous structures based on pre-required function. Finally, the main advances in catalytic applications of porous materials are presented, pointing out that 'the grand challenge for catalysis science in the 21st century is to understand how to design catalyst structure to control catalytic activity and selectivity'.

The second chapter introduces the structural characteristics of zeolites and related microporous materials. This is a key subject since the fascinating properties of microporous materials, such as ion-exchange, separation, catalysis and their role as host in nanocomposite solids are essentially determined by their unique structural characteristics such as pore window, the accessible void space, the dimensionality of the channel system, the number and sites of

cations, etc. After listing the main structural types of zeolites, the authors present the structural building units of zeolites, their compositions and framework structure.

The final part of this chapter is devoted to structural aspects of the zeolite-related microporous materials (open-framework materials) such as aluminophosphates, gallophosphates, zinc, iron, nickel and vanadium phosphates, germanates and indium sulfides, whose discovery has been promoting enormous increase in the chemical variety of inorganic porous materials.

Chapter 3 *Synthetic Chemistry of Microporous Compounds (I) – Fundamentals and Synthetic Routes* is allocated to synthesis and related fundamental principles, synthetic approaches and techniques for conventional microporous materials such as zeolites and aluminophosphates. The chapter starts with basic concepts of hidro(solvo)thermal synthesis, which is the core of the synthetic chemistry of microporous crystals. The second part deals with the preparation approaches as well as basic synthetic laws for microporous compounds, covering hydrothermal, solvothermal and microwave synthesis techniques, followed by the advanced synthesis through hydrothermal treatment in the fluoride media. This part is completed with the topic of modern applications of combinatorial synthesis to prepare new microporous solids. The final part of this chapter aims to state and discuss the typical and representative synthetic procedures for those microporous molecular sieves which nowadays are widely used in catalysis and other fields of science and advanced technologies.

Owing to the increasingly wider range of applications, the newly developed microporous materials of special composition, structure and aggregated states are reviewed in Chapter 4, the focus being put on their synthetic chemistry. This chapter is organized into two parts. One introduces the microporous solids having special composition such as the M(III)X(V)O_4-type, oxide-, sulfide- and aluminoborate-type, and special structure such as extra-large microporous channels, interconnecting 2- and 3-dimensional channel systems, chiral channels and various cage structure. The other part deals with microporous compounds displaying special morphologies such as nano-size and ultra-fine particles, perfect crystals and single crystals, microsphere, coating, film, membrane and special crystal morphologies, etc.

Chapter 5 *Crystallization of Microporous Compounds*, whose central part is the crystallization process to form the microporous framework, is focused on several key chemistry aspects related to crystallization such as source materials for preparing the inorganic phase and the involved condensation reactions, crystallization process and proposed mechanistic pathways of zeolite formation as well as the templating effect of organic structure directing agents and crystallization kinetic.

The understanding of these fundamental issues must help researchers to explore and develop new synthetic strategies to obtain microporous molecular sieves.

Chapter 6 analyzed the postsynthesis strategies which result in the improvement of the zeolite properties and functions such as acidity, thermal and hydrothermal stability, catalytic performance, pore structure and surface properties. Moreover, new properties of zeolites can be obtained, which are not easily achieved by conventional direct hydrothermal synthesis. After treating the issue of template removal from microporous compounds to obtain the porous system, the authors described the major secondary synthesis and modification strategies: cation-exchange and modification of zeolites, isomorphous substitution of heteroatoms in zeolite framework and channel and surface modification of zeolites.

A presentation of the frontier research issues in molecular engineering as a modern tool to create new molecular sieves is provided in Chapter 7. After a short introduction in the field, the structure prediction methods for designing and synthesizing inorganic microporous materials are reviewed. In the subsequent part, a discussion is included which is related to the rational synthesis of microporous compounds. It covers some new synthetic approaches such as data-mining-aided methods, template-directed methods, combinatorial routes as well as buiding-block built-up routes.

Mesoporous molecular sieves play an important role in expanding the application of porous materials. The flexibility and complexity of their synthesis and structures and their perspectives in application created a high opportunity for both academic and industrial research. The key issues on synthesis, structure and characterization of mesoporous materials are included in Chapter 8. After an introductory part on the main structural types of mesoporous materials, attention was paid to synthesis chemical characteristics and proposed formation mechanisms of ordered mesoporous materials. Subsequently, the evolution of the research on the structure and synthesis of mesoporous silica was presented. This part covers the 2-D hexagonal, cubic and caged ordered mesoporous materials as well as the disordered ones.

The methods which allow controlling the pore size in mesoporous materials are discussed in the next part, which is followed by the main synthesis strategies used nowadays to produce such solids.

The new compositions of mesoporous materials others than silica are also reviewed, including nonsilica materials, metal-doped mesoporous silicas, hybrid organic-inorganic mesostructure as well as metal oxides, phosphates, semiconductors, carbons and metallic mesoporous materials. Then, the focus was put on the morphology and macroscopic form of mesoporous materials. The chapter is ended by some possible applications of mesoporous materials, challenges and an outlook.

Chapter 9 *Porous Host-Guest Advanced Materials* focuses on the developments of another cutting-edge research field, i.e., host-guest porous materials and MOFs solids, which includes the most promising directions in finding new applications of these advanced materials, such as metal clusters, dyes, polymers, carbons, nano-semiconductors in zeolites as host materials, metal complex in molecular sieves and metal-organic porous coordination polymers.

The literature has been covered up to 2006, an extensive list of references being included at the end of each chapter. Finally, all nine chapters include a large number of reaction schemes, figures, tables and experimental details which makes the present book more enjoyable to read.

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