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# NANOPOROUS MATERIALS II

Proceedings of the 2nd Conference on Access in Nanoporous Materials,  
Banff, Alberta, Canada, May 25-30, 2000

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## PREFACE

The first symposium on Access in Nanoporous Materials was held in Lansing, Michigan on June 7-9, 1995. The five years that have passed since that initial meeting have brought remarkable advances in all aspects of this growing family of materials. In particular, impressive progress has been achieved in the area of novel self-assembled mesoporous materials, their synthesis, characterization and applications. The supramolecular self-assembly of various inorganic and organic species into ordered mesostructures became a powerful method for synthesis of mesoporous molecular sieves of tailored framework composition, pore structure, pore size and desired surface functionality for advanced applications in such areas as separation, adsorption, catalysis, environmental cleanup and nanotechnology. Over 2000 papers have been published on self-assembled mesoporous materials since 1992 and more than 90% of these papers have appeared in just the last five years. The growth in this area of materials research has been truly remarkable.

In addition to mesostructured metal oxide molecular sieves prepared through supramolecular assembly pathways, clays, carbon molecular sieves, porous polymers, sol-gel and imprinted materials, as well as self-assembled organic and other zeolite-like materials, have captured the attention of materials researchers around the globe. Clays, zeolites and sol-gel materials are still very popular because of their extensive and expanding applications in catalysis and separation science. Novel carbons and polymers of ordered porous structures have been synthesized. There are almost unlimited opportunities in the synthesis of new organic materials of desired structural and surface properties via self-assembly or imprinting procedures.

The contents of the current volume presents a sampling of more than 150 oral and poster papers delivered at the Symposium on Access in Nanoporous Materials II held in Banff, Alberta on May 25-28, 2000. The selected papers cover the three main themes of the symposium: (i) synthesis of mesoporous silicas, framework-modified mesoporous silicas, and surface-modified mesoporous silicas, (ii) synthesis of other nanoporous and nanostructured materials, and (iii) characterization and applications of nanoporous materials. About 70% of the papers are devoted to the synthesis of siliceous mesoporous molecular sieves, their modification, characterization and applications, which represent the current research trend in nanoporous materials. The remaining contributions provide some indications on the future developments in the area of non-siliceous molecular sieves and related materials. Although the present book does not cover all topics in the area of nanoporous materials, it reflects the current trends and advances in this area, which will certainly attract the attention of materials chemists in the 21<sup>st</sup> Century.

Abdel Sayari  
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January 20, 2000

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## A novel approach to polymer-template mesoporous molecular sieves

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A novel synthesis route was developed to produce spherical silica particles. The synthesis is based on a modified Stoeber method and the room-temperature synthesis of MCM 41S-materials applying tetraethoxysilane, alcohol, water, ammonia and homopolymers as template. The specific surface area, the specific pore volume and the average pore diameter were varied in the following ranges: 5 – 1,000 m<sup>2</sup>/g; 0.1 – 1.0 cm<sup>3</sup>/g and 2 – 50 nm. With respect to catalytic applications hetero-atoms e.g. Al were incorporated into the silica framework.

### 1. INTRODUCTION

The pioneering work on the synthesis of ordered mesoporous silicas of the type M41S by Mobil researchers has led to the design of periodic porous silicas with pore sizes between 2 and 10 nm using low-molecular weight templates e.g. n-hexadecyltrimethylammonium bromide [1]. For the use of polymer as a template several pathways are reported in the literature. Pinnavaia et al. [2] prepared mesoporous molecular sieves using polyethylenoxide as a surfactant. Wiesner et al. [3] used block copolymer phases for the synthesis of aluminosilicate mesostructures with different morphologies. Triblock copolymers were employed as structure-directing agents by Stucky [4] and his co-workers resulting in hexagonal ordered mesoporous silicas. Mercier et al. synthesized organically functionalized mesostructured materials using non-ionic polyethylenoxide surfactant [5]. MSU-X mesoporous silicates prepared from non-ionic polyethylenoxide were reported by Bagshaw [6].

We have combined these approaches of pore size engineering with another synthesis route where uniform spherical particles are obtained in the micron and submicron size range [7]. The latter procedure allows one to adjust the particle size and size distribution of the silica particles by the reaction conditions.