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The Sol-Gel Technology of Porous Composites

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The present work analyzes patterns of change, composition, structure and properties of porous composite materials, and presents the main types of them. The selection of chemicals that have the greatest thermal stability and fire resistance was carried out. Physical and chemical characteristics of main porous refractory materials were shown. The materials with regular and quasi-regular pore structure, as well as materials with the pore structure of opal are given as the example.

The analysis of the pore system in the structure of solid bodies has been performed by the example of packing spherical nanoparticles and fibrous. Fractal and hierarchical structure of

porous composite materials, including foam-regular porous materials were shown.

The main methods to create porous inorganic composite materials were demostrated. A new method to produce porous materials by ultra-deep penetration is described in details. General methods for the preparation of raw materials in the production of porous inorganic composite materials and methods of forming them are also described.

The use of various inorganic binders for heat-resistant, porous composite materials: water glass; alkali metal polysilicates; colloids, silica sols, and alumina-sols and oxides sols of various metals; metal alkoxides; organometallic siloxanes; inorganic binders based on various compounds of chemical elements has been proposed. A special analysis of the possible use of soluble silicates as precursors in the sol-gel technology for porous nanocomposites was conducted.

Fundamentals of sol-gel technology for inorganic composites and ceramics, particularly alkoxides hydrolytic and non-hydrolytic sol-gel methods for synthesis have been described. The authors considered the colloidal the method of sol-gel synthesis in details. Methods for preparing of metal oxides sols, the effect of various factors on the stability of sols and their use for the preparation of inorganic composite materials, and ceramics have been shown.

Analysis of different methods to study the composition, structure and properties of the synthesized sols and porous materials based on them was performed. Special attention was paid to the study of particle size distribution of sols using chemical and physico-chemical methods. In particular, methods of ultracentrifugation, electron microscopy and optical-electronic methods to determine the dispersion of the particles in the sols. A new highly sensitive rheology method to investigate colloidal dispersions and the sol-gel transition was proposed. The authors demonstarte how the study of porous structure of inorganic composite by means of the mercury porosimetry may be used to determine density and pore structure of porous materials.

The authors attentively observe the production process of silica sol by an ion exchange method and study of its properties. Mathematical modeling of the properties and behavior of individual particles of silica sol and the influence of the composition of the liquid phase on the stability of silica sol was conducted. In addition, the authors elaborated on the processes for

the production of alumina-sols and research their properties. To do this they analyzed the state of the aluminum ions Al^{3+} in aqueous solutions. The phase transformations in systems of aluminum salts, its oxides and hydrated oxides were discribed. Methods for production of alumina-sols by precipitation-peptization; synthesis ion exchange, the controlled hydrolysis of aluminum compounds have been proposed. The interactions between silica sols and alumina sols were investigated in order to obtain highly dispersed alumino-silicate mixed systems. A new method for the introduction of a binder in nanodispersed compositions - homogeneous precipitation of hydrated alumina has been described.

The results of research with new fundamental results and dedicated to the processes of curing systems based on liquid glass and aqueous solutions of silicates, silica sol gelation, including rheological methods were presented. Influence of silica sol characteristics, on the properties of obtained xerogels was investigated.

Basic approaches to the modeling of hardening in the dispersed silicate systems using the methods of quasi-homogeneous approximation, the statistical method of polymer and fractal methods have been described in this monograph. Condition of colloidal solutions of silica was described in terms of statistical physics, using the Maxwell-Boltzmann distribution. The main approaches to model the kinetics of the sol-gel transition with the Boltzmann equation and formal kinetic descriptions were shown. The authors reveal some aspects of physical and chemical description of the sol-gel transition in forming thin films during the deposition of particles of hydrated aluminum oxide on the surface of the substrate.

Methods to create porous refractory composite materials, fiber based, using the methods of sol-gel technology have been demonstrated. Possibilities of application of different binders for formation porous composite materials were analyzed. Influence of processing factors on the properties of the resulting fibrous lightweight thermal protection materials, including increased strength and density was shown. The physical, mechanical and thermal properties of the lightweight thermal protection materials were studied. Test results of inorganic fiber based thermal barrier materials mullite-silica fibers and binders based on aluminum and silicon oxides were presented. Technological recommendations for the preparation of porous lightweight thermal protection materials have been proposed.

This monograph is intended for a wide range of scientists, engineers and practitioners, as well as teachers, graduate students and senior students of technical colleges and universities, for the advanced study the foundations of technology of porous nanocomposite materials based on oxides.

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