Aerogels

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These proceedings contain 60 reports from the 3rd International Symposium on Aerogels, held in Würzburg (Germany) at the end of 1991. The editor of these proceedings, Professor Fricke, chairman of the organizational committee and organizer of this and preceding symposia, is a leader in the field of aerogels. He was able to collect in these proceedings the works of leading specialists in this field, so that this book reflects the present status of the problem.

An aerogel is a porous material with a high specific surface area (up to 1500 g/m^2) and low density (down to 3 g/liter). The history of aerogels starts in the 1930s, when the American scientist Kistler proposed a technology for fabricating these materials. Aerogel production technology is now central to the problem of aerogels. An aerogel is prepared in an autoclave at supercritical solutions parameters. This makes it possible to eliminate the molecules in the pores of an aerogel. A number of papers presented at this symposium are devoted to the detailed analysis of the processes occurring here. Thus the parameters of the condensation process of an aerogel in solution have been determined for the most widely used SiO_2 aerogel (the activation energy is 4.7 kJ/mole, the order of the reaction with respect to the concentration of hydroxyl ions in solution is 0.7). The development, by American scientists, of a two-step method for producing aerosols should be especially noted. This method makes it possible to lower the aerosol density to 3 g/liter while maintaining uniformity and transparency.

Comparing the aerogel investigations presented at this symposium to previous investigations (see, for example, the works presented at the first symposium on aerogels[1] and their review in Ref. 2) shows that the range of aerogels is now much larger. Previously the chemical composition of aerogels was limited to several oxides, mainly SiO_2. The range of oxides employed in aerogels has been expanded somewhat and now includes organic aerogels.

Significant effort in aerogel research is devoted to the structure and physical properties of aerogels. Modern methods for measuring structural factors employ small-angle scattering of neutrons and x-rays. These methods make it possible to determine the details of aerogel structure, including aerogel fractal properties in some size range. Several works are devoted to aerogel optical properties in the infrared, ultraviolet, and optical regions of the spectrum. The method of nuclear magnetic resonance is used to analyze the properties of aerogels. Thus all possible existing physical methods are used to investigate aerogels.

A number of interesting investigations of the physical properties of aerogels have been performed. Investigation of gas flow through an aerogel makes it possible to determine in detail the interaction of gas atoms with the inner surface of the aerogel. Measurements of the thermal conductivity and heat capacity of an aerogel show that these quantities vary by several orders of magnitude over the temperature range 0.1–330 K. The character of the change in the thermophysical parameters of aerogels at low temperatures are analyzed. Propagation of ultrasonic and sound waves in aerogels and the associated mechanical properties of aerogels are investigated.

A number of physical properties and applications of aerogels are considered: optical and thermal properties of aerogels, associated with their use as window insulators and solar collectors, as well as materials for foam insulation. The acoustic properties of aerogels are associated with the low speed of sound in them (lower than in air), which depends in the conventional manner on the aerosol density. The acoustic properties of an aerogel are employed in the aerogel-based production of acoustic systems for sound transmission and reflection. These applications of aerogels are promising, but they have not yet found practical applications. The main application of aerogels—as a material in Cherenkov detectors—has long ago justified the efforts expended on aerosol research. At this symposium a new variant of this direction, pertaining to investigation of thermal muonia (muonium is a system similar to atomic hydrogen and consisting of a μ^+ meson and an electron), which are stopped with the help of aerogel plates, is discussed. Another example is the use of aerogels as a catalyzer. A palladium catalyzer is presented, the palladium being an additive to an aerogel based on aluminum oxides. The properties of the catalyzer are demonstrated for CO and NO oxidation processes.

Thus aerogels, as a specific physical object, have their own place in scientific research. Interest in this object is largely connected with its possible applications as a material, but the fundamental aspect of aerogel research is just as important. An aerogel, being a strongly rarefied porous material, is a solid that manifests simultaneously the properties of a gas, since the most of the volume of an aerogel consists of pores. In some range of the parameters an aerogel exhibits fractal properties. This specific feature of aerogels is attracting attention to them. These proceedings reflect the present status of aerogel research.

[1] J. Fricke [Ed.], *Aerogels*, Springer-Verlag, Berlin, 1986.
[2] B. M. Smirnov, Usp. Fiz. Nauk **151**, 733 (1987) [Sov. Phys. Usp. **30**, 350 (1987)].

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