Aerogels

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Sols are individual particles in a liquid or gaseous phase, gels are systems of coupled sols. Aerogels are light structures formed of individual particles. The reality of the existence of such structures has been understood in recent years, and the present book is a collection of the proceedings of the First International Symposium on Aerogels which took place in September 1985 in the Federal Republic of Germany.

The interest in aerogels is along two directions. First, they are unique physical objects with specific properties. The principal part of the articles of the book is devoted to the properties of aerogels. Secondly, the special properties of aerogels enable finding a number of possibilities of utilizing them for applied purposes. A significant part of the articles in the book is devoted to the applied aspects of the problem.

The aerogels under discussion are in their chemical composition SiO_2 with a number of water molecules. The molecules of silicon dioxide can be replaced in an aerogel by other oxides Al_2O_3, ZrO_2, M_gO, MoO_2, Fe_3O_4, TiO_2, Li_2O, B_2O_3, etc. However, silicagel—an aerogel based on silicon dioxide—constitutes the principal part of the investigations. The size of the particles in an aerogel varies approximately from 3 to 60 nm depending on the conditions under which it was obtained. The aerogel itself has the structure of a fractal cluster [cf.: Usp. Fiz. Nauk **149**, 177 (1986); Sov. Phys. Usp. **29**, 481 (1986)], i.e., the particles are joined in it according to random law, and the density of matter in such a cluster is the lower the greater is its size. Formation of an

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aerogel takes place in the liquid phase, and then the liquid phase is evaporated. In addition to water methol and ethyl alcohols, carbon dioxide gas, xenon and other fillers are used as liquids. They are chosen in such a manner that the evaporation of the liquid contained within the pores of the aerogel would take place at not very high temperatures and would not destroy the structure of the aerogel.

In spite of the simplicity in principle of obtaining an aerogel the mastering and reduction in cost of the technology of its production will play an important role in future investigations of aerogels. Present-day technology enables one to obtain aerogels in large quantities. As an example we shall point to the production of 1700 liters of silicon arogel accomplished several years ago for the Cherenkov detector TASSO at the DESY accelerator in Hamburg. The cost of the aerogel within the framework of present-day technology is relatively high.

The special property of an aerogel as a fractal cluster is related to its high porosity. In actual samples of a silicon aerogel the volume of the pores occupies up to 99% of the volume of the sample, so that the internal surface of the sample amounts up to 1,000 m^2/g. Therefore aerogels can be utilized for storing oxidizers, rocket fuel and different chemical compounds. In this connection they are characterized by high capacity. For example, 40 g of antisymmetric dimethylhydrazine can be stored in 1 g of silicon aerogel.

The high specific surface of aerogels promises that they will be widely used as catalyzers. Some examples of this type have been found.

An important property of silicon aerogel is associated with its transparency. As the density of the aerogel is decreased the coefficient of retraction of light in it n also decreases and actually lies within the range between 1.007 and 1.24. Materials which it is convenient to utilize as detectors of high energy particles have coefficients of refraction which do not lie in this range. Therefore silicon aerogels are utilized in Cherenkov detectors for recording fast particles—pions, kaons, protons.

As a result of the low density of matter in aerogels which in actual fact amounts to tens and hundreds of grams per liter aerogels have a low thermal conductivity. The thermal conductivity of real aerogels is comparable with the thermal conductivity of gases. Therefore methods are being developed to utilize silicon aerogels as insulators in different instruments placed in the atmosphere, and also as insulation materials in construction. In this conection the high transparency of silicon aerogel provides the possibility of utilizing it as an insulating material between window panes.

As a result of their structure aerogels have unique acoustical properties. The low speed of propagation of sound in aerogels (down to 100 m/s) enables one to use it in different applications: for the preparation of sound-impenetrable partitions, sound delay lines, different acoustical systems, including systems with directed propagation of sound. It is clear that the scale of these and earlier mentioned applications of aerogels is determined to a large extent by their availability and cost.

The problems enumerated above associated with the properties and applications of aerogels constitute the content of the book under review.

The book consists of 5 parts: 1) Introduction. 2) Production and general aspects. 3) Storage of energy and thermal properties. 4) Structure of aerogels. 5) Applications. It includes 25 articles, which in length are greater and in content are somewhat broader than the usual original communications at conferences.

An aerogel is a physical object with unusual properties. It can be of interest for specialists in solid state physics, in atmospheric physics, in physics and chemistry of surfaces, and in synergetics, for whom the physical and chemical properties of this object are essential. For specialists in energy production, in thermal physics, in high energy physics, and in chemical synthesis aerogels are interesting in a purely applied aspect. In this connection it is essential to note that scientists are at an early stage of investigating aerogels when it has become clear that this object is formed both in nature and under laboratory conditions, but the investigation of its properties and possible applications are far from having been exhausted. It is all the more important to achieve a timely understanding of the place which this object can occupy in science and technology. The book under review can give a good picture of this.

Translated by G. M. Volkoff