



## Professor Sergey Petrovich Zhdanov: 90th Birthday on April 18, 2002



One of the world's leading experts in synthesis of zeolitic molecular sieves becomes ninety years old: *Sergey Petrovich Zhdanov*. He was born in a small Russian village, Pechevka, close to Tambov and south-east of Moscow, at a distance of about 800 km (500 miles) from St. Petersburg, on April 18, 1912. He came to Leningrad, now St. Petersburg again, for education, which he received at the State University, and where he had been spending most of his life. His particular interest in biology and its chemical fundamentals

was nurtured by his studies at the Institute of Plant Protection. S.P. Zhdanov's first scientific work (1934) was devoted to the problem of Caucasian locust, and results of this research became a subject of a lively correspondence between him and V.P. Uvarov who was a curator of the British Museum of Natural History, London, during that time. In 1938, S.P. Zhdanov graduated from the Chemical Faculty of the Leningrad University. Thereafter, he joined the Zoological Institute where he organized a laboratory of

hydrochemistry. During that period, one of the main results of his research was the elucidation of reasons for fish dying in the Volga River during wintertime. As to so many, World War II became a long and bitter break to S.P. Zhdanov, and he had to change the labcoat to the great-coat as worn by soldiers.

After World War II, S.P. Zhdanov received doctorates in chemical sciences at the Leningrad State Optical Institute. He joined the Institute of Silicate Chemistry of the Academy of Sciences of the USSR, Leningrad, in 1955, becoming Head of the Laboratory of Silicate Sorbents in 1962. He became a Full Professor of Physical Chemistry in 1970. Since 1959 and without interruption, S.P. Zhdanov had been serving as a member of the *Scientific Council on Adsorbents* of the USSR Academy of Sciences. He became one of the world's leading experts in synthesis of inorganic materials, especially zeolitic molecular sieves—a class of microporous adsorbents, without which modern fluid-phase separation and purification processes by the unit operation “adsorption” cannot be imagined.

S.P. Zhdanov began his research into zeolites during the late 1950s, and his first scientific publication in this area was published in 1961 (Zhdanov and Buntar, 1961). His work had a strong impact and contributed to the rapid growth of zeolite science and technology, as was soon acknowledged by the international community in this area. In 1967, the Organizing Committee of the 1st International Conference on Molecular Sieves invited S.P. Zhdanov to present a paper on fundamentals of zeolite synthesis. By that time, he had already gained a high international reputation, and his name was known as well among the experts in the fields of glass science, surface chemistry, and noncrystalline porous materials.

S.P. Zhdanov had twice been elected a member of the Executive Committee of the Council of the *International Zeolite Association*. In 1981, he was awarded the title of a *Honoree in Science and Engineering of the Republic of Russia*.

At the beginning of the 1960s, S.P. Zhdanov suggested a novel method for the representation of results of zeolite crystallization in four-component systems (Zhdanov et al., 1963). Ever since, triangular sections in the composition tetrahedron have been used practically in all papers on zeolite synthesis. In 1965, S.P. Zhdanov first published the results of a separate determination of the compositions of liquid and solid phases in aluminosilicate synthesis gels, which were precursors of zeolites (Zhdanov et al., 1965). He

revealed that the nature of the products of crystallization could be changed as a result of the change of intermicellar liquid without any modification of the gel skeleton. This work had provided the basis for an elucidation of the crystallization mechanism. Evidence for the idea of a dominating role of the liquid phase in the course of zeolite formation was provided by S.P. Zhdanov as main topic of his presentation at the 1st International Conference on Molecular Sieves in London (Zhdanov, 1968). According to that concept, the nucleation of zeolite crystals starts in the liquid phase and their growth under quasi-equilibrium conditions is due to a progressive dissolution of the amorphous solid phase. At present this view is indisputable.

At the 2nd International Zeolite Conference held in 1971, S.P. Zhdanov reported a method for determining the linear rate of zeolite crystal growth (Zhdanov, 1971). This rate was determined from dimensions of the largest crystals measured at various times. It was assumed that, at initial stages, crystals of different sizes grow at the same rate, which depends only on temperature and components' concentrations in the reaction mixture. This assumption resulted into a novel method to calculate the actual number of crystals, which is based on the crystal size distribution for the final synthesis product. A differentiation of these curves allows the time dependences of the nucleation rate to be obtained. S.P. Zhdanov had convincingly demonstrated that an increase in this rate is observed only at the initial stage of crystallization despite formation of *nuclei* during the entire process. This work had been crucial in the evolution of studies on zeolite crystallization, since it enabled the crystal growth and nucleation to be characterized quantitatively at any stage of zeolite formation. This turned out to be a key to understanding the nature of different stages of crystallization as well as the mechanisms of seeding and gel aging.

A few years later, S.P. Zhdanov and N.N. Samulevich provided the first quantitative description of the experimental sigmoid crystallization curves (Zhdanov and Samulevich, 1978). At the 5th International Conference on Zeolites in 1980, they introduced the method of calculation of such curves (Zhdanov and Samulevich, 1980). These calculations require only the histogram of the crystal-size distribution in the final product and the values of linear growth rates for the largest crystals. The results obtained were in full agreement with relevant X-ray data.

S.P. Zhdanov was the first to offer an hypothesis on the acceleration of crystallization and decrease in

crystal sizes of zeolites after gel aging as a result of nucleation and increase of the number of *nuclei* during the aging period (Zhdanov, 1973). Soon afterwards, this predictive approach was confirmed experimentally in his laboratory (Zhdanov and Samulevich, 1978). S.P. Zhdanov discovered the presence of *extrema* in the dependences of crystallization time and total number of crystal *nuclei* on aging temperature, in 1985 (Zhdanov, 1985). As shown in Zhdanov et al. (1991), the influence of gel aging at ambient temperature on both crystallization rate and crystal size represents a special case only, of a general dependence of these parameters on nucleation temperature. A pronounced increase in crystallization rate was also found after gel freezing (Zhdanov et al., 1991).

S.P. Zhdanov not only made important contributions to zeolite synthesis but also to various other fields of inorganic and physical chemistry. His pioneering efforts in the application of far-infrared spectroscopy to the study of zeolites (Brodskiy et al., 1971) initiated an intense activity in this area. In 1969 (Ryskin et al., 1969), a team of researchers headed by S.P. Zhdanov, first observed the splitting of the stretching mode of acid hydroxyls in IR-spectra of zeolites upon adsorption of some weak bases. They explained this finding in terms of strong hydrogen-bond formation. Only two decades later, the attention of researchers became focused on this phenomenon, with a lively discussion being currently in progress.

S.P. Zhdanov and his colleagues summarized results of their work in the two-volume monograph “*Synthetic Zeolites*” (Gordon and Breach, NY, 1990). This book had been a most comprehensive treatise of synthesis of zeolites in connection with a thoughtful description of their adsorption properties.

During the 1970s and 1980s, S.P. Zhdanov played a leading role in a strong and successful scientific collaboration between zeolite research groups of Academies of Sciences of several former European socialist countries. He influenced strongly the successful synthesis of microporous materials in those countries, as well as their characterization and usage for a series of practical purposes. Synthesis of comparatively large and pure zeolite crystals performed in his laboratory was particularly stimulating in answering fundamental questions related to the mobility of guest molecules in zeolite host environments.

S.P. Zhdanov continues to work at the Institute of Silicate Chemistry of the Russian Academy of Sciences. His most recent paper (Titova et al., 2001) is devoted

to advantages of the IR-spectroscopic investigation of building and tuning chemical bonds in zeolite frameworks. He also continues to work in the glass-chemistry field, where his contribution is as essential as that in zeolite chemistry.

All colleagues and friends, which are spread worldwide, wish Sergey Petrovich Zhdanov strong health and a long and fruitful life, during which, besides chemistry, he ought to find time to indulge in music, most of all Tchaikovski and Rakhmaninov but also Beethoven and Wagner, in painting and in ballet (the great corps de ballet of his beloved St. Petersburg!), as well as in skiing, which give him so much strength!

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