

Academician Mikhail G. VORONKOV**A TRIBUTE**

Professor Mikhail G. Voronkov is known throughout the world of science as a distinguished specialist in organic, physical-organic and especially element-organic chemistry. Born on December 6, 1921, in the town of Oryol, M. G. Voronkov joined the Chemistry Department of the Leningrad State University in 1938. In July 1941 he volunteered for the Soviet Army; that December he suffered concussion and was released from the military service. In 1942 he was evacuated from blockaded Leningrad to Sverdlovsk (the Ural Region), where he rapidly graduated from the local University. After a spell as postgraduate at the Institute of Organic Chemistry, USSR Academy of Sciences (Kazan-Moscow), he returned to his Alma mater at Leningrad as lecturer and subsequently senior scientist in Organic Chemistry (1944-1954). He became successively Head of the Laboratory of Inorganic Polymers at the Institute of Chemistry of Silicates, USSR Academy of Sciences (1954-1991) and Head of the Laboratory of Element-organic Compounds at the Institute of Organic Synthesis, Latvian Academy of Sciences (1961-1970). From 1970 to 1994 M. G. Voronkov was the Director of the Irkutsk Institute of Organic Chemistry, Siberian Branch of the USSR Academy of Sciences. Since 1995 he is a Scientific Adviser of the Russian Academy of Sciences and Head of the Laboratory of Element-organic Compounds at the same Institute.

The scientific career of M.G. Voronkov had an auspicious start. He belonged to three well-known schools of chemistry headed by Academicians A. E. Favorsky, N. D. Zelensky and V. N. Ipatiev. Already as a first and second year undergraduate, he conducted research under the

supervision of Professor S. A. Shchukarev and Assistant Professor V. I. Egorov, trusted co-worker of Academician A. E. Favorsky. Later he was fortunate to work under the leadership of Professors Yu. K. Yuriev and R. Ya. Levina at Moscow State University, and Professor B. N. Dolgov, (a disciple of V. N. Ipatiev) at the Leningrad State University. In 1942, as graduate student of Academician A. E. Favorsky and F. M. Shostakovsky (future Corresponding Member of the Academy of Sciences of the USSR) he commenced research on alkyl vinyl ethers that later continued (after 1970) at IrIOCh.

From 1944 to 1948 at the Leningrad University, M.G. Voronkov investigated reactions of sulfur with organic compounds. Investigation of the reaction of sulfur with phenylalkenes and phenylalkadienes laid the foundation of his dissertation for the Candidate of Sciences degree (1947). These studies were continued at the Institute of Organic Synthesis, Latvian Academy of Sciences (1962-1970), and led to the discovery of several previously unknown classes of organosulfur compounds and many new reactions, one of which (the interaction of sulfur with arylchloroalkanes and -alkenes) was named "the Voronkov reaction". The results of this research were summarized in a monograph "The reactions of sulfur with organic compounds" published in the USSR, the United States and Great Britain.

Since 1948 the scientific interests of M.G. Voronkov have focussed on the chemistry of organosilicon compounds. He was the first scientist worldwide to investigate heterolytic cleavage of the Si-O-Si group. For these studies he was awarded the degree of Doctor of Sciences (1961). Pioneering investigations of biologically active silicon compounds led to the discovery of substances with unique effects on living organisms, and M.G. Voronkov thus created a new branch of silicon chemistry, namely bioorganosilicon chemistry. A comprehensive account of this work has been published in the monographs "Silicon and Life" (translated into German and published in the German Democratic Republic), "Silicon in Living Nature" (translated into Japanese) and "A wonderful element for life".

M.G. Voronkov's fundamental studies in the chemistry, physical chemistry, biology, and pharmacology of silatranes and other hypervalent silicon compounds (dragonoids, derivatives of azoles, amides, hydrazides of carboxylic acids, *etc.*) received worldwide recognition. Silatranes turned out to be a new class of physiologically active substances that have already found many applications in agriculture and medicine. For the creation and development of the chemistry of pentacoordinate silicon M. G. Voronkov was awarded the State Prize of the Russian Federation in 1997.

He was the first Russian scientist who investigated organosilicon compounds with Si-H bonds, sulfur-containing organic compounds of silicon, and element-organosilicon compounds containing B, Al, Sn, Sb, P, As, Ti, V, Mo heteroatoms. His research in the field of organosilicon and element-organosilicon compounds has been summarized in seven monographs published in the USSR, United States and Great Britain. These include "Siloxane bonding", a fundamental monograph (USSR, USA) and "Heterosiloxanes", a set of three comprehensive and detailed volumes published in Russian and in English.

Under the guidance of M. G. Voronkov numerous original and profound studies have been undertaken in the field of carbon-functionalized, unsaturated macrocyclic, high-molecular and bioactive organosilicon compounds. Especially noteworthy in this research are nitrogen-containing organosilicon compounds (derivatives of amino alcohols and amino acids, nitrogen-containing heterocycles), and monomers and polymers with silicon-linked substituents containing nitrogen and/or sulfur atoms.

M. G. Voronkov frequently employed quantum chemical methods at a high level of theory and diverse physicochemical methods for the study of organic and element-organic compounds (IR-, UV- Raman- and photoelectron spectroscopy; mass-spectrometry, ^1H , ^{13}C , ^{15}N , ^{19}F , ^{29}Si NMR; NQR, EPR; dielcometry, refractometry; X-ray structural analysis, Kerr effect, calorimetry, polarography, *etc.*) These methods were used to interpret the individualities of the molecular and electronic structures of the element-organic and organic compounds under investigation. He was a pioneer of in-depth investigation of chlorine-containing organosilicon compounds using NQR, and also the first to define the dependence of ^{35}Cl NQR frequencies on the electronic effect of substituents at the central C, Si and Ge atom, as well as on the length of polymethylene chain in aliphatic mono- and dichlorides. He also utilized the EPR method in biochemistry and medicine.

Recently, M. G. Voronkov's attention has been attracted by new, less readily accessible classes of organic compounds of sulfur (α -halo-thioketones, α -halo-gem-dithiols, dithiiranes, condensed heterocyclic systems, 1,2-dithiolene-3-thiones, *etc.*), arylheteroacetic acid derivatives as effective biostimulants and adaptogens, and organic derivatives of germanium, tin, phosphorus and fluorine. A series of studies is devoted to the high temperature synthesis and thermal transformations of organosulfur compounds involving sulfenyl radicals. The Me_3SiI -assisted cleavage of C-O-C, C-O-Si and Si-O-Si groups was discovered by him and is now widely used in organic and organosilicon synthesis.

M. G. Voronkov developed and theoretically substantiated the processes of hydrophobization and surface modification of materials using organosilicon monomers and oligomers. His original inventions have been applied with success in industry, agriculture and medicine: biostimulants, adaptogens, microbiological synthesis catalysts, hydrophobic and bioprotective organosilicon coatings, sorbents and ion-exchangers, special materials for use in electronics, universal aqueous quencher, lubricant additives, materials for special fields of engineering, *etc.* A series of unique drugs (feracryl, acyzolum, trecrezan, silacast, silimin, dibutyryn, cobazol, *etc.*) was developed under his leadership.

For the development and successful application of polymolecular organosilicon coatings he was awarded the State Prize of the Ukrainian Republic (1982). In 1983 he received the title "Honorary chemist of the USSR", and his name is included in the "Book of Honor" of the Ministry of Chemical Industry. He is also a recipient of the

Premium of the USSR Council of Ministers for creation of organosilicon materials for the use in microelectronics and special ceramics (1991).

Recently, Voronkov has investigated liquid-phase organosilicon reactions under mild conditions involving the intermediate formation of silanone. During these studies new reactions of Si-C and Si-O bond cleavage by gallium and indium triiodides and tribromides were found for peralkyldisiloxanes; these reactions proceed through the intermediate formation of dialkylsilanones. Dialkylsilanones are intermediates of a number of organosilicon reactions, *e.g.* the reaction of organylchlorosilane with DMSO and the oxides of some metals; electrochemical reaction of diorganylchlorosilane with superoxide or peroxide anions and others. As a result, he elaborated a new theory concerning the processes of formation and breakdown of siloxane structures with silanones as intermediates. He has discovered organosilicon superbases like $XCH_2Si(OCH_2CH)_3N$ ($X = N, O, S, Cl$) which are presently under examination.

A number of his investigations have been devoted to organogermanium and organotin compounds. He had the insight to recognize the complex class of pentacoordinate germanium organic compounds - organylgermatranes, and investigated their physicochemical properties and biological activity. Valuable contributions to the organotin chemistry included his studies of compounds containing Sn-S bonds, hypervalent tin atoms, homolytic addition reactions to alkenylstannanes, and the possibility of using organotin compounds in organic synthesis, *etc.*

Numerous publications were devoted to the use of Zr, Na, K, Mg, Hg, B, Al, Ga, In, Ti, P, As, Sb, Se, Te, V, Mo, Fe, Co, Ni and platinoids as reagents and catalysts.

The results of his research of half a century are contained in over 2000 scientific papers, 200 of which were published abroad, in 37 monographs (of which 15 were published in the United States, Great Britain, Germany, Japan, Poland, Romania), in 60 review articles published in Russian and in foreign journals, and in many popular science papers. He is also the author or co-author of about 500 Inventor's Certificates (USSR) and over 50 foreign patents.

30 Doctors of Sciences (D. Sc. equivalent) and over 180 Candidates of Sciences (Ph. D) equivalent have studied under Voronkov.

His extensive research work was combined successfully with vigorous organizing and social activities. For a quarter of a century (1970-1994) he was Director of the Irkutsk Institute of Organic Chemistry, Siberian Branch of the USSR (Russian) Academy of Sciences. From 1973 to 1984 he was Vice-President of the Presidium of the East-Siberian Affiliation (later the Irkutsk Scientific Center) of the Siberian Branch of the USSR Academy of Sciences. He was General Director of the Research and Production Association "Chemist". Since 1986 he has been Vice-Chairman or Chairman of the Scientific Council on "Chemistry and Technology of Organic Compounds of Sulfur" of the Ministry of Science and Technology, Russian Federation. In 1966 M. G. Voronkov was elected Corresponding Member of the Latvian Academy of Sciences, and in 1970 Corresponding Member of the USSR Academy of Sciences. In recognition of his distinguished service to chemistry he received the title of Academician in 1990..

M. G. Voronkov is a member of three Departments and two Scientific Councils of the RAS, of the Editorial Board of *Journal of General Chemistry* (Russia) and three international journals: *Journal of Organometallic Chemistry*, *Inorganic and Metalloorganic Synthesis and Reactivity*,

and *Chemistry of Heterocyclic Compounds*, and of the international electronic chemical journal *ARKIVOC*.

He has been an organizer and/or Associate Editor-in-Chief of *Izvestiya Akademii Nauk, Latv. SSR, Ser. Khim. and Khimia Geterotsiklicheskih soedinenii*, a member of the Editorial Board of: *Metalloorganicheskaya Khimia* and *Sibirskii Khimicheskii Zhurnal*, a compiler and a managing editor of *The Chemistry and Practical Application of Organosilicon Compounds* (Russia) in 6 Volumes (Leningrad, 1958, 1961) and a collection of reviews *Achievements of Organosilicon Chemistry in the USSR* (Moscow, 1988) published in English.

His numerous and outstanding contributions to international chemistry have been acknowledged on several occasions. In 1975 he received an honorary doctorate (*Doctor honoris causa*) from Politechnika Gdanska. He was elected a Corresponding Member of the Braunschweig Scientific Society in 1976, of the Chemical Society of Japan in 1990, and a Foreign Member of the Latvian Academy of Sciences and a Member of the Union of Latvian Chemists in 1992. He is a member of the International Society for Environmental and Health Research (SIRES), an Honorary Member of the Asia-Pacific Academy of Advances Materials (1998) and of the Florida Center of Heterocyclic Chemistry (USA, 1990). For his Activities in the development of chemical science in Mongolia he was awarded the medal of the Academy of Sciences of the Mongolian People's Republic. The Government of Mongolia awarded him the medal of Friendship and the order of the Polar Star.

Voronkov was the second most frequently cited Soviet chemist in 1981-1985 and the third most prolific scientist in the world as reported by *The Scientist* in 1990. At present, according to recent Internet data he was the fourth most frequently cited Russian chemist in the period from 1981 to 1997.

M.G. Voronkov took part in many international conferences and in nearly all international symposia on organosilicon chemistry as a member of the Organizing Committee and/or plenary lecturer. He presented a plenary lecture at the 40th Nobel Symposium "Biochemistry of Silicon and Related Problems", in Stockholm, 1977.

He was chief scientist of many investigations carried out in collaboration with universities and institutes of the German Democratic Republic, Czechoslovakia, Poland, Hungary and Mongolia. Studies were undertaken under his guidance by chemists from the United States, West Germany, Ukraine and Uzbekistan.

He is a veteran of the Great Patriotic War (World War II) and took part in the defense of Leningrad. He was awarded the orders of "Great Patriotic War", "Red Banner of Labor", "Friendship of Peoples" and "For Great Services for the Motherland", and 18 medals.

Voronkov's chronological and biological ages do not correspond. He continues to be distinguished by his prodigious capacity for work, unceasing stream of original ideas, wide scope of interests, devoted love for science, benevolence to his co-workers and colleagues, and good sense of humor. He is still doing much research in the Irkutsk Institute of Chemistry. He is a scientific adviser of the Russian Academy of Sciences and consultant of many chemical

enterprises, scientific centers and institutes of Russia, Ukraine, China and Mongolia. He presented his recent research results at five international conferences in 1997 and 1998.

Professor Boris A. Trofimov
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