Russian Chemical Reviews **78** (8) 679 – 681 (2009) © 2009 Russian Academy of Sciences and Turpion Ltd

DOI 10.1070/RC2009v078n08ABEH004085

N D Zelinsky Institute of Organic Chemistry of the Russian Academy of Sciences



This issue of the journal is compiled from reviews written by researchers of the N D Zelinsky Institute of Organic Chemistry (IOC RAS), one of the leading chemical research institutes of the Russian Academy of Sciences, which celebrates its 75th anniversary in 2009.

The Institute was established by a Resolution of the Presidium of the USSR Academy of Sciences dated 23rd February, 1934, and was organized by joining representation of leading scientific schools from Moscow and Leningrad (now St Petersburg). The backbone of the Institute was composed of the research groups of academicians A E Favorsky, N D Zelinsky and his associates, V N Ipatyev and A E Chichibabin. The laboratories of academicians N Ya Demyanov, P P Shorygin and honorary academicians M A Il'yinsky and N M Kizhner also joined the Institute. Thus, from the early outset IOC comprised the elite of Russian organic chemistry and related sciences.

Enourmous contributions to the formation and development of the Institute were made by its directors — academicians A E Favorsky (1934 – 1939), A N Nesmeyanov (1939 – 1954), B A Kazansky (1954 – 1966), N K Kochetkov (1966 – 1988) and V A Tartakovsky (1988 – 2002). Since 2003, IOC has been headed by academician M P Egorov. In 1953 the Institute received the name of N D Zelinsky, and in 1984 IOC was awarded the Order of the Red Banner of Labour for achievements in the development of chemical science and in the training of scientific manpower.

IOC's fruitful investigations gave rise to new branches of research and the corresponding R&D groups. This resulted in establishment of several new institutes of the Academy of Sciences including the Institute of Organoelement Compounds (1954), the Institute of High-Pressure Physics (1954) and the Institute of Chemistry of Natural Compounds (1959, now the Institute of Bioorganic Chemistry). IOC was also actively involved in the establishment of the Irkutsk Institute of Organic Chemistry of the Siberian Branch of the Academy of Sciences (now Irkutsk Institute of Chemistry). N D Zelinsky Institute of Organic Chemistry made a major contribution towards training scientific manpower of highest qualification for Russia, former Soviet republics (now independent states) and other countries. Many researchers of the Institute of Bioorganic Chemistry in Minsk (Belarus), the Institute of Organic Chemistry in Bishkek (Kyrgyzstan), Institutes of Chemistry in Dushanbe (Tajikistan) and Ashkhabad (Turkmenistan) graduated from IOC.

The worldwide reputation of the Institute is due to the names of outstanding scientists who carried out their studies at IOC in different years. In addition to the abovementioned academicians A E Favorsky, N D Zelinsky, V N Ipatyev, A E Chichibabin, N Ya Demyanov and P P Shorygin, full members of the Academy of Sciences A A Balandin, L F Vereshchagin, M I Kabachnik, I L Knunyants, V V Korshak, Kh M Minachev, I N Nazarov, V M Rodionov, M M Shemyakin, corresponding members of the Academy of Sciences B M Mikhailov, A M Moiseenkov, S S Novikov, A D Petrov, V A Ponomarenko, I V Torgov, N I Shuikin, P P Shorygin and many others worked at the Institute. Remarkable contributions to the national and world chemical science made by academicians N D Zelinsky, A N Nesmeyanov, A A Balandin, V N Ipatyev and M M Shemyakin were commemorated in the corresponding named prizes (scientific awards) of the Academy of Sciences.

Nowadays, the Institute has highly qualified scientific personnel, which, for the most part, determine the face of the national and world chemical science. Academicians

Yu N Bubnov, M P Egorov, N S Zefirov, V B Kazansky, O M Nefedov, V A Tartakovsky, corresponding members of the RAS V P Ananikov, A L Lapidus, G I Nikishin, E P Serebryakov make their research at IOC. The Institute totally comprises 456 research staff including 83 Doctors of Sciences and 237 PhDs. Their fruitful studies are marked by high state awards and titles. Among currently working associates there are 11 order-bearers; more than 30 laureates of the Lenin and State Prizes and also the Prizes of the USSR Council of Ministers and the Government of the Russian Federation, the Demidov Prize, named prizes of the RAS and international awards; 14 laureates of the Lenin Komsomol Prize, the awards and medals of the RAS and awards for young scientists of the European Academy. Nine scientists received the honorary title 'Meritorious Scientist of the Russian Federation'. IOC leading scientists represent Russia in international scientific organizations and belong to the members of foreing academies and scientific societies. They are also the members of advisory and editorial boards of international journals.

The Institute has made a number of major scientific achievements. A new physical phenomenon, the resonance combination (Raman) scattering, which is currently successfully used in the study of organic compounds, has been discovered. Research techniques for studying the structure and reactivity of organic compounds (including short-lived intermediates) under normal and extreme conditions have been developed and are successfully employed. Their applications include the direct study of unstable species (carbenes, free radicals and other intermediates) in low-temperature inert matrices and in the gas phase, flash photolysis, radiospectroscopy and elemental analysis.

The Institute is generally recognized for developments in chemistry of unsaturated compounds, demonstrating virtually unlimited potential for the synthesis of a wide variety of aliphatic, alicyclic and heterocyclic systems including natural compounds. The Institute is also renowned for its works on the chemistry of carbenes and their analogues, small rings and diazo compounds. These investigations resulted in the development of a highly efficient hydrocarbon fuel for innovative machinery, environmentally friendly insecticides of the pyrethroid series, and also fluoroquinolone antibiotics. Scientists of IOC made a significant contribution towards studying the problem of double bonding involving the silicon and germanium atoms.

The world largest scientific school in the chemistry of nitro compounds, which is now being successfully developed, has been established in IOC. The scientists of this school obtained results that guaranteed a solid footing of our country in the field of highly energetic substances. The Institute carries out studies on the chemical conversion of explosives, which particularly allowed complex processing of TNT to new practically valuable products. New application areas of aliphatic and aromatic nitro compounds in organic synthesis have been found.

One of the main lines of research conducted at IOC is the chemistry of heterocycles. Studies on the chemitry of thiophene, pyridine and azoles gained worldwide recognition. In recent years, works on the synthesis of photochromic dihetarylethenes have been successfully developed. The investigation into homolytic reactions opened up new horizons for the preparative synthesis of aliphatic and alicyclic functional compounds, thiacrown ethers, lactones including macrocyclic ones. Outstanding achievements were reached in the chemistry of organoboranes, in both the development of new methods of their preparation and their application to organic synthesis.

Studies on organic electrochemistry at the Institute have been widely recognized. They are associated with the development of unique methods of electrosynthesis including those based on new approaches to the generation of reactive intermediates of ionic or radical nature. They also apply to the development of new principles of environmentally friendly preparation of useful products. Studies on the synthesis of heterochain polymers are being successfully developed.

For more than 40 years, IOC has been conducting fundamental research in the chemistry and biochemistry of carbohydrates. Original approaches to studying the structure of complex natural carbohydrates have been created. They resulted in the determination of structures of a number of polysaccharides from bacteria and seaweeds and of animal glycolipids and glycoproteins. An invaluable contribution to the synthetic chemistry of carbohydrates has been made by the development of novel methods of the stereodirected formation of a glycosidic bond, which found application in the synthesis of oligosaccharides, homo- and heteropolysaccharides and neoglycoconjugates that can be used for new types of vaccines and diagnostics. The pathways of biosynthesis of carbohydrate antigens of a number of bacteria have been studied, and chemical and chemoenzymatic synthesis of the antigens and their analogues has been accomplished. Original studies on the synthesis of steroids led to the development of first national hormonal agents with separated biological functions.

The Institute performed a number of fundamental works in the theory of organic catalysis. The principles of the multiplet catalysis theory constituting a scientific foundation of the targeted selection of catalysts have been developed. Elementary steps of a number of catalytic reactions, and also the structures and physical properties of catalyst surfaces were examined with the use of, among others, quantum chemistry approaches and a complex of state-of-the-art instrumental methods. Fundamental research was also conducted in the area of the catalytic transformations of hydrocarbons and the synthesis of various products based on carbon monoxide and other one-carbon molecules. The scientific principles of the manufacturing of catalysts based on domestic zeolites have been created. Highly efficient environmentally friendly catalytic processes for the preparation of isopentane, high-octane petrols, ethylbenzene and isopropylbenzene have been developed. Catalysts for the synthesis of isoprene, styrene, conversion of hydrocarbons to components of engine fuels, *etc*. have been created. Kinetic, physical and mathematical models for the simulation of industrial processes and reactors have been constructed. Studies on asymmetric and metal complex catalysis are in progress.

On the basis of the scientific studies, the research staff of the Institute published many thousands of scientific papers, around 150 monographs and proceedings, more than ten textbooks and student's guides (many of them were run into several editions and translated into foreign languages). IOC reseachers are the authors of hundreds of inventions.

IOC scientists combine fundamental scientific research with the solution of practical problems of paramount importance. Fundamental studies at the IOC laid the foundations for many industrial processes.

In years of the Great Patriotic war, the Institute developed the so-called carbinol glue (Nazarov's glue) for

repairing military equipment in the field and a technique for reinforcing artillery and mortar barrels; found ways of increasing the quality of aviation petrols; developed methods of synthesis of a number of drugs including the wound-healing preparation Vinilin (Shostakovsky's balsam) and performed their large-scale production.

Based on the IOC developments, the Institute jointly with other research groups launched the industrial production of Cyclin (a unique hydrocarbon fuel), synthetic pyrethroids (broad-spectrum insecticides), organic phosphors (bases for the manufacturing of day fluorescent paint, 'labelled sands', *etc*.), polyfluoroorganosiloxanes (bases of lubricants), many pharmaceutical substances, in particular, acrichine, vitamins B_1, B_6, A and E, promedol, vinilin, hemodez, cygerol, mebicar, tribenol, potassium orotate, octicyl, lysozyme, pencrofton and also desthiobiotin (a biostimulant to the growth of bakery yeast), and pefloxacin (an antibacterial agent). The processes for manufacturing of butadiene, allyl acetate and acetopropyl acetate have been developed and introduced into industry. The production of high-performance catalysts for various industrial processes has been organized. Among them are the hydrogenation of fats, the preparation of extra pure industrial gases, the purification of synthesis gas, the syntheses of liquid hydrocarbons, ceresins and acetic acid based on CO, *etc*. A method of the isolation and purification of the antibiotic streptomycin has been developed. Methods of the recovery and disposal of nonferrous metals from galvanic effluents have been introduced. Exceptionally efficient components of solid and liquid rocket propellants have been created. The Institute gives much attention to the development of the rational methods of synthesis of biodegradable polymers, novel crop and animal protection chemicals and to the creation of a new generation of diagnostica and vaccines.

The collaboration between the Institute scientists and the affiliated Special Design Bureau in the years 1959–1994 on the development of various laboratory instruments, first of all, chromatographs and on their widespread introduction into industry played an important role in the evolution of the national scientific instrumentation industry.

Since the late 1980s, new trends in theoretical chemistry including mathematical chemistry, computer-aided synthesis, simulation of chemical processes have been successfully developed at IOC. The use of state-of-the-art information technologies is expanding. Quantum chemical calculation approaches to modelling natural high molecular weight compounds are being developed. The search for ways to increase the performance of quantum chemical software on account of the architecture optimization of computer clusters is being carried out.

The following successfully operating resources are based in IOC RAS: The Centre of Computer Assistance in Chemical Research of RAS, the FREEnet scientific and educational network, the Moscow Information Centre STN International, the International Analytical Laboratory (IOC jointly with the Bruker company) and the Eco-Analytical Centre. Since 2005 the Innovation and Technology Department has been working at IOC.

In the 1990s, the Institute associates played an active role in the establishement of an effective system of continuing education comprising Moscow Chemical Lyceum (MCL) – Higher Chemical College of the RAS (HCC) – PhD study — Doctor of Sciences study at IOC. Important units of this system are the Scientific and Educational Centre IOC – MCL and the Scientific and Training Centre IOC – HCC organized at the Institute. A branch of a department of the Gubkin Russian State University of Oil and Gas and the joint scientific and educational centre Gas Chemistry at IOC also fall into this category. At present, 50 PhD and Doctor of Sciences students conduct their studies at the Institute.

The Institute is an organizer of the Mendeleev meetings on general and applied chemistry, youth science schools, conferences on the chemistry of carbenes, nitro compounds, heterocyclic and organosulfur compounds, carbohydrates, on catalysis and mechanisms of catalytic reactions and also on the use of information technologies in chemical research.

The Institute associates are actively involved in the publication of leading scientific journals of the Russian Academy of Sciences, *viz*., Izvestiya Akademii Nauk. Seriya Khimicheskaya (Russian Chemical Bulletin, International Edition) and Uspekhi Khimii (Russian Chemical Reviews) a co-founder of which is IOC RAS. The editorial offices of the Kinetika i Kataliz (Kinetics and Catalysis) and Mendeleev Communications journals are also located in IOC.

The articles by IOC research staff published in this and several previous issues of the journal reflect only a few research fields existing at the Institute. For more detailed information on the laboratories of IOC and publications by our scientists the reader is referred to the Institute web-site www.ioc.ac.ru.

Director of IOC RAS,
Academician M P Egorov