



**International  
Arbuzovs Prize  
in Organophosphorus Chemistry**

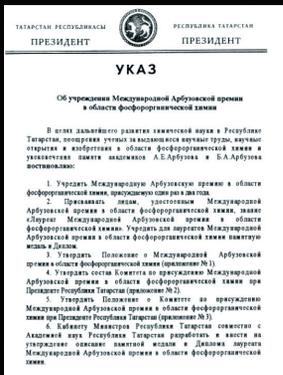




Aleksander Ermingeldovich Arbuzov



Boris Aleksandrovich Arbuzov



Decree establishing the International Arbuzovs Prize in the field of organophosphorus chemistry.



On July 11,1997, at the threshold of the 120th anniversary of academician Alexander Arbuzov, an outstanding Russian chemist and originator of a new chemical branch — chemistry of organophosphorus compounds, President of the Republic of Tatarstan Mintimer Shaimiev signed the Decree establishing the International Arbuzovs Prize in the field of organophosphorus chemistry.

According to the Regulations “About the International Arbuzovs Prize in the field of organophosphorus chemistry”:

*“...The Arbuzovs Prize, established in memory of the outstanding Russian chemists Alexander and Boris Arbuzovs, is awarded to an honored chemist for a single scientific achievement or a set of scientific results. The Arbuzovs Prize is given by the President of the Republic of Tatarstan biennially on the birthday of academician Alexander Arbuzov personally to Russian or foreign scientist.”*







*Kazan and Kazan Chemical School have played a significant role in the history of science. Here, on the bank of the Volga river, in the city, where «the East meets the West», in the middle of the XIX century the scientific school was developed, that gave the world a group of researchers whose works are now a part of the «gold fund» of the world chemical science.*

*Here K. Klaus discovered a new element Ruthenium (Russain), N.Zinin performed the reduction of nitrobenzene into aniline, A. Butlerov laid the foundation of modern organic chemistry. In the XX century Alexander and Boris Arbuzovs became their successors.*

**T**he name of Alexander Arbuzov (1877—1968) is connected with the creation of a new chemical field: the chemistry of organophosphorus compounds. This field laid the foundation of the so-called “third chemistry”, the chemistry of organoelement compounds. The reaction, discovered by Alexander Arbuzov and named after him, became the “main road” for the synthesis of organophosphorus compounds.

Boris Arbuzov (1903—1991), his farther’s successor, was also a world-famous scientist. The scope of B.Arbusov’s scientific interests was extremely wide. The major fields of his research work were the chemistry of organophosphorus compounds, the chemistry of terpenes, the chemistry of unsaturated compounds, and the stereochemistry of organic substances. His greatest discoveries were made in the field of physiologically active compounds and tightly connected with studies of his predecessors: A. Butlerov, V. Markovnikov, A. Zaitzev, F. Flavitzki, and A. Arbuzov.

A. Arbuzov and B. Arbuzov were both the prominent chemists and the important public figures. Their role as the organizers of science in Kazan can not be overestimated. They headed Kazan Chemistry School for about a century, and almost all achievements in organic chemistry which were made in Kazan at that time are connected with their names.





## Arkady PUDOVIK

(Russia) (1916-2006)

*Corresponding Member of the Russian Academy of Sciences, Honorary Academician of the Academy of Sciences of Tatarstan, Lenin prize winner, Director of the A.E.Arbusov Institute, Freeman of Kazan*

**A**rkady Pudovik is one of the most remarkable representatives of Kazan Chemistry School, the disciple of academicians Alexander and Boris Arbusovs. He discovered a new addition reaction of hydrophosphoryl compounds and their thioanalogues to unsaturated reagents with homo- and heterodouble bonds. "Pudovik's Reaction" is the unique way for obtaining organophosphorus compounds with P-C bonds.

Arkady Pudovik made considerable contribution into the investigation of the reaction of trivalent phosphorus derivatives with electrophilic reagents - a "nonclassical" version of the Arbusov's reaction. This reaction allowed the synthesis of a wide range of different linear and cyclic organophosphorus compounds.

He revealed that vinylphosphonic acid

ethers add various nucleophilic reagents against the Rule of Markovnikov. This method of synthesis of  $\beta$ -functionalized alkylphosphonates was named "phospho-nethylation reaction".

Arkady Pudovik successfully developed the chemistry of heterocyclic phosphorus derivatives. Original methods for synthesis of saturated and unsaturated phosphacyclanes were found.

For 55 years of his scientific activity he published about 1400 papers, 3 monographs and 20 surveys. Under his supervision more than 70 Ph.D. theses were defended and 20 his followers got Doctor's degrees.





## Louis QUIN

(U.S.A.) (1928)

*Professor Emeritus of the University of Massachusetts at Amherst, and Duke University of North Carolina at Durham, President of the International Union on Main Group Chemistry*



Louis Quin is well known by his works in the field of the conformational analysis of phosphorus heterocycles, the synthesis and reactivity of low coordination phosphorus compounds, and the application of  $^{31}\text{P}$  NMR spectroscopy for studying the dynamic stereochemistry of phosphorus compounds.

Prof. Quin laid the foundation for a new field of the phosphorus chemistry — the chemistry of heterocyclic phosphorus compounds. He has synthesized phospholenes, investigated their reactivity and stereochemistry and developed the methods of synthesis of polycyclic compounds. He has made considerable contribution into phosphole chemistry. He was the first discovered cis-trans isomerism in cyclic phosphines with a single chiral center — the atom of phosphorus, and then a new

line of research was developed, including the investigation of isomerism and conformation analysis of 6-membered heterocycles.

He revealed that the introduction of oxygen into P-C bond results in the formation of thermally unstable products, which are converted into highly reactive phosphoryl compounds of low coordination easily. He explained such effects as descreening by  $\beta$ -atoms of carbon and screening by  $\gamma$ -atoms of carbon.





## Jan MICHALSKI

(Poland) (1920-2016)

*Professor, Director of the Center  
of Molecular and Macromolecular Studies,  
Polish Academy of Sciences at Lodz*

**J**an Michalski is the founder of the organophosphorus chemistry school in Poland and one of undisputed leaders in organophosphorus chemistry for more than 40 years. He is the author of over 350 papers and co-author of 4 monographs on the organophosphorus compounds chemistry.

Prof. Michalski is recognized for his pioneering work in the field of trivalent phosphorus stereochemistry as well as the chemistry of thio- and seleno-phosphoryl compounds. He was one of the first to use  $^{31}\text{P}$  NMR spectroscopy together with stereochemical studies to elucidate the mechanisms of important reactions in phosphorus chemistry. Michalski developed also methods for chemo- and stereoselective phosphorylation of natural products. His development of the concept

of organophosphorus pseudohalogenes, which became an important tool in the synthesis of sulfur- and selenium-organic compounds as well as in general organic synthesis, is of particular importance.

Prof. Michalski is the member of Polish, France, and Berlin Academies of Sciences. He was awarded different international prizes including the Medals for scientific achievements of Paris, Polish Chemical Society, and Japan.





## Francois MATHEY

(France) (1941)

*President of the French Chemical Society,  
Member of the Academy of Sciences  
of Paris, Professor of Chemistry  
in the Ecological Polytechnic Institute  
and the National Center on Scientific  
Investigations in Paris*



**F**rancois Mathey is well known authority in organophosphorus chemistry. F. Mathey has authored about 500 papers and 32 patents; mainly he has contributed to the development of phosphorus-carbon heterocyclic chemistry.

He has performed for the first time the synthesis of phosphirene ring, developed the chemistry of 2H-phospholes, 1-phosphanorbornadienes, phosphinines, polyphosphorus macrocycles with planar phosphorus atoms. He has synthesized numerous  $\eta^5$ -phospha-cyclopentadienyl complexes with group III to IX transition metals. He has started to develop the chemistry of electrophilic terminal phosphinidene complexes, behaving as singlet carbenes. Another significant contribution is the synthesis of compounds with P=C double bonds from carbonyl

derivatives via the phospho-Wittig reaction. The use of phosphoferrocenes in asymmetric catalysis and phosphazirconocenes in polymerization catalysis is currently under his active investigation.

Francois Mathey is the member of a few of international scientific societies including the Royal Society of Chemistry (UK) and the European Academy of Sciences. He has received the Alexander von Humboldt award, the Silver Medal of CNRS, the Main Group Chemistry award and many others. Francois Mathey is the editor-in-chief of the Journal "Heteroatom Chemistry".





The awarding ceremony  
of the International  
Arbuzovs Prize in the Field  
of Organophosphorus  
Chemistry – 2005



The awarding ceremony of the  
International Arbuzovs Prize in the Field  
of Organophosphorus Chemistry – 2007





There is a traditional musical introduction before a report of the Laureate of the International Arbuszovs Prize in the Field of Organophosphorus Chemistry. State string quartet of the Republic of Tatarstan performs a fragment from opera "Prince Igor" by Alexander Borodin, Russian composer and scientist-chemist.





## Edgar NIECKE

(Germany) (1939)

*Professor of Chemistry,  
Director of the Department  
of Inorganic Chemistry,  
University of Bonn*

**E**dgar Niecke is one of the most well-known chemists of the XX century and founders of the modern organophosphorus chemistry school in Germany.

His primary research concerns the development of molecular compounds having phosphorus-element-( $\pi$ - $\pi$ )-bonds and, thus, phosphorus in low coordination. Experimental and theoretical structure and reactivity studies were carried out on a broad variety of systems such as iminophosphanes (behaving as singlet carbenes), phosphalkenes, bis(ylene) phosphoranes, phosphallylic and phosphacarbene systems, monomeric metaphosphate analogues, as well as other unconventional compounds such as iminophosphonium and methylenediylphosphonium cations. The discovery of stable E- and Z-diphosphenes and the charac-

terization of umbrella-shaped species are worthy of special attention.

His current activities are focused on two research fields:

1. Design of tridentate hybrid ligands with low-coordinated phosphorus centers for the synthesis of novel macrocycles containing ligands with discriminative functionalities and redox activities and
2. Chemistry of unique stable diradical phosphorus heterocyclic systems, 1,3-diphosphetane-2,4-diyls, which are enabled to react as crypto-carbenes and/or can undergo mesolytic fragmentations. A long term perspective of the latter research is to develop the chemistry of phosphorus-containing polyradicals as non-metallic magnets.





**Masaaki  
YOSHIFUJI**

(Japan) (1941)

*Professor at Tohoku University  
in Sendai*



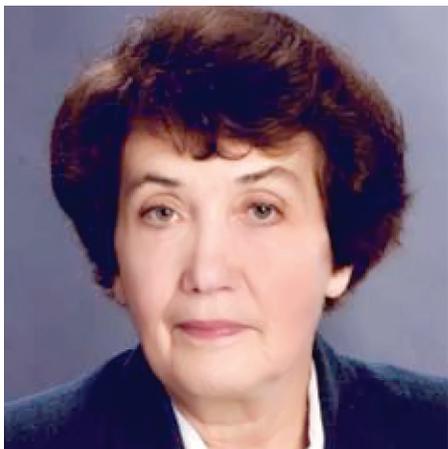
**M**asaaki Yoshifuji has gained a worldwide recognition when he described the first genuine phosphorus-phosphorus double bond in a famous paper published in the *J. Am. Chem. Soc.* in 1981.

The stabilization of this first diphosphene  $RP=PR$  was achieved by using very bulky substituents providing the double bond with a sufficient kinetic stability. This finding led to a complete reevaluation of the so-called double-bond rule forbidding the existence of stable double bonds between heavy elements. Following this breakthrough, Prof. Yoshifuji investigated the stabilization of a bunch of low-coordinated phosphorus species including phosphalkenes, phosphadienes, phosphacumulenes, phosphalkynes, etc. using bulky substituents and developed

their chemistry. Recently, he started to investigate the possible uses of these new species as ligands in homogeneous catalysis.

Professor Yoshifuji has authored or co-authored about 250 papers in Japanese and international journals, has received the Alexander von Humboldt award, and has organized the 15th International Conference on Phosphorus Chemistry in 2001 in Sendai. He is clearly one of the prominent organophosphorus chemists in activity.





**Irina  
BELETSKAYA**

*(Russia) (1933)*

*Full Member of the Russian Academy of Science, Professor of Moscow State University, Head of the Laboratory of Organoelement Compounds*

**I**rina Beletskaya is recognized authority in the field of organic and organophosphorous compounds chemistry, chemistry of metalloorganic compounds, and homogeneous metallocomplex catalysis in organic synthesis. She is the author of about 1000 papers and 6 monographs, and the head of world-famous scientific school.

The area of her scientific research — use of the metallocomplex catalysis in organic and metalloorganic synthesis, new methods for generation of essential chemical compounds including biologically active analogues of natural substances and medical products.

Academician Irina Beletskaya has made considerable contribution into development of the chemistry of organophosphorous compounds. For the first time the P-H and P-P bonds addition reactions catalyzed by Pd and Ni complexes to alkynes and

alkenes were performed. These reactions can be accomplished with high regio- and stereoselectivity. Also first an enantioselective addition of dialkylphosphites to an asymmetrical double bond in the chiral rhodium complexes catalysis was achieved. P-analogues of medical products used extensively were obtained.

Irina Beletskaya is the laureate of different Russian and international prizes. She has received the State Prize of the Russian Federation, the Lomonosov and Mendeleev awards, Sweden Prize “Women in engineering sciences” and many others. She is the editor-in-chief of the Russian Journal of Organic Chemistry, the member of INTAS Scientific Council, and the President of Organic Chemistry Department of International Union of Pure and Applied Chemistry (IUPAC).





## Marian MIKOLAJCZYK

(Poland) (1937)

*Professor of Organic Chemistry,  
Full Member of the Polish Academy  
of Sciences, Director of the Centre  
of Molecular and Macromolecular Studies,  
Polish Academy of Sciences, Lodz*



**M**arian Mikołajczyk is widely recognized as one of the leading organophosphorus chemists.

He has provided many contributions to: synthetic organophosphorus chemistry, stereochemistry and physical chemistry of organophosphorus compounds, chemistry and stereochemistry of organosulfur compounds, synthetic chemistry. He has directed his skill and experience in heteroorganic chemistry towards the solution of problems on: nucleophilic substitution at the chiral phosphorus and sulfur atom, mechanism of the reaction between carbodiimides and thio- and selenoacids, synthesis of chiral trivalent phosphorus compounds; anomeric effect phosphorus substituted in cyclic sulfur and selenium compounds. Starting from 1985 attention was also paid to the synthesis of 1,4-dicarbonyl systems, cyclopentanoid antibiotics, prostaglandins and carbocyclic nucleosides using new organosulfur and

organophosphorus reagents. During the last decade he contributed greatly to the development of enzymatic heteroatom chemistry.

The scientific achievements of Professor Marian Mikołajczyk are numerous; most of them are of fundamental importance and were widely cited in the chemical literature.

Marian Mikołajczyk is the winner of many prizes including: Award of the Polish Chemical Society, State award of Poland, and Alexander von Humboldt Research Award. He is Doctor Honoris Causa of the Paul Sabatier University, Toulouse (France) and of the Technical University, Lodz. Professor M. Mikołajczyk has worked as the Visiting Professor at the universities of Germany, France, Israel, USA, and Brazil. He is a member of some international scientific associations: Polish Chemical Society, International Union for Pure and Applied Chemistry (IUPAC), International Council on Main Group Chemistry, German Chemical Society.





**George Michael  
BLACKBURN**

*(United Kingdom) (1935)*

*Professor of Chemical Biology, Department of Molecular Biology & Biotechnology, the University of Sheffield*

**M**ichael Blackburn has graduated University of Cambridge as Rockefeller Research Fellow in 1956. He performed his investigations under the supervision of Professor Lord Todd, Nobel Laureate. He was a Visiting Professor in Biochemistry in some universities of USA, Australia, Japan, PR China and other countries. However the biggest part of his scientific career is connected with University of Sheffield.

Considerable contribution into bioorganic chemistry, phosphorus chemistry, physical-organic chemistry, and basic enzymology made by Michael Blackburn cannot be overestimated. His most important achievements are closely connected with investigations of mechanism of enzyme-catalysed phosphoryl transfer, especially phosphatases and kinases. He designed non-hydrolysable nucleotide analogues incorporating various substituted bisphosphonates and trisphosphonates for studies on DNA repair enzymes and AdoMet processes including histone

methylation. His investigations in the field of catalytic antibodies - from mechanism to cancer chemotherapy, are pioneer works. Professor Blackburn initiated research of phosphatase using selection technology as well studies with synthetic analogues of rare adenosine nucleotides - especially for cell-signalling. Now he is actively working in the area of enzyme inhibitors chemistry, especially for carbonic anhydrase and glaucoma therapy.

Prof. Blackburn is author of over 270 research papers in learned journals and three books as well the author and co-author of some 12 patents on bisphosphonates, on drug development for histone methylase inhibitors, on topical treatment of glaucoma, and on drug developments for avian influenza neuraminidase.

He is the member of many prestigious international scientific organizations as well the member of editorial boards of some scientific journals.





## Valery KUKHAR

(Ukraine) (1942 - 2017)

*Academician of the National Academy of Sciences of Ukraine (NASU), Director of the Institute of Bioorganic Chemistry and Petrochemistry, NASU.*



**P**rofessor Valery Kukhar is a world-known scientist. The main field of his scientific interest is bioorganic chemistry and fine organic synthesis of fluorine and phosphorus analogs of natural compounds, phosphorus containing amino acids as well chemical and technological aspects of environment protection, asymmetric synthesis. Since the beginning of his career, he is successfully continuing the way of fathers in phosphorus chemistry like Arbuzovs, Kirsanov, Kabachnik or Michalski and his impact on the development of phosphorus chemistry is enormous: phosphorus derivatives of  $\alpha$ -chloroalkylamines, chlorophosphazopolychloroalkanes, phosphoruscontaining haloenolides, aminophosphorous acids, asymmetric synthesis, bio-active compounds.

Valery Kukhar is being a leader in phosphorus chemistry for many years and has a

distinguished publication record. He is the author of more 600 papers and about 20 review articles in refereed journals as well co-author of 6 monographs. His major achievement in phosphorus chemistry is a fundamental book "Aminophosphonic and Aminophosphinic Acids. Chemistry and Biological Activity" (in English) published in co-authorship with Harry Hudson.

Valerii Kukhar is the laureate of different prizes including A. Kiprianov Award of NASU, State Award in Science & Technology (Ukraine), San-Valentino Award, World Federation of

Scientists, Memorable Medal "In Memory of Academician N.M. Emanuel", and others.





## XXI International Conference on Phosphorus Chemistry

**I**n June 2016 the important scientific forum - the XXI International Conference on Phosphorus Chemistry was held under the patronage of the President of the Republic of Tatarstan in Kazan (21st ICPC).

These Conferences are conducted under the auspices of the International Union of Pure and Applied Chemistry in the biggest scientific centers of the world as a rule biennially. The First Conference took place in 1964 in Germany. For the first time the Conference, during more than fifty years history was held in Russia. This fact can be considered as an

international recognition of the important contribution of Russian chemists including some generations of the world-famous Kazan Chemistry School into the world science. Besides Kazan is one of the biggest and most important cultural, educational, scientific, and industrial centers of Russia. This ancient city with millennial history is the place where deep historical roots are combined harmoniously with dynamic, rapid development of region. Kazan is a multi-religious city, where religious tolerance is the guarantor of the security in today's troubled world.





In the frame of the 21st ICPC Opening Ceremony the President of the Republic of Tatarstan presented the International Arbuzovs Prize-2015 to Professor Yufen Zhao (China) for her great contribution into fundamental phosphorus chemistry.

“It’s a big honour for me to get this Prize. The name of Alexander Arbuzov is well known in China, not only in universities but also in

schools too. He is the great scientist, and his contribution into chemistry will not be overestimated. It’s my first visit to Kazan. Kazan is a very beautiful city, but first of all I would like to express my admiration by the development of science in Tatarstan and especially by attention and kindness to scientific problems from the Tatarstan Government”, said Prof. Zhao.



President of the Republic of Tatarstan Rustam Minnikhanov is greeting the Arbuzovs Prize winners of different years and inviting them to the table with national Tatar sweets and tea.



Patron of the Conference Rustam Minnikhanov with Arbuzov's laureates - participants of the Conference.

**From left to right:** Marian Mikołajczyk (Poland), Masaaki Yoshifuji (Japan), President of the Republic of Tatarstan Rustam Minnikhanov, Yufen Zhao (China), Michael Blackburn (United Kingdom), Francois Mathey (France)





## Yufen ZHAO

*(China) (1948)*

*Academician of the Chinese Academy of Sciences,*

*Professor of Chemistry at the Xiamen University*

**Y**ufen ZHAO is well known authority and specialist in the organophosphorus chemistry field as well in the adjoining fields. A set of scientific achievements were made by Professor Yufen Zhao in the following important directions: Phosphorus Chemistry and Origin of Life; Penta-Coordinate Phosphorus Chemistry; P-C Bond Formation; Medicinal Chemistry; Mass Spectrometry Analysis; <sup>31</sup>P NMR and Theoretical Computation.

She is author and co-author of more than 800 publications in top-level international chemical and biochemical journals. Especially important contribution was made by Professor Zhao into the field of the origin of the Earth life and the medicinal chemistry.

For the first time it was demonstrated the high-energy P-N bond might have participated in the evolution of prebiotic chemistry.

N-phosphoryl amino acids (PAAs) can serve as interesting small molecular models for the P-N bond in prebiotic chemical evolution. PAAs are capable of simultaneously producing several important biomolecules such as polypeptides and oligonucleotides under mild reaction conditions. The remarkable reaction of N-phosphoryl amino acids with nucleoside mixtures, forming peptides and oligonucleotides simultaneously, suggests a pathway of 'co-evolution of proteins and nucleic acids'.

Professor Zhao presented an evolution model of modern protease and nuclease. The dipeptide Ser-His is the shortest peptide ever reported to show cleavage activity with multiple categories of natural substrates, such as DNA, protein, the ester p-NPA and RNA.





## Manfred SCHEER

(Germany) (1955)

*Full Professor of Chemistry at the Institute  
of Inorganic Chemistry,  
University of Regensburg*



**M**anfred Scheer is a world-known specialist in the field of phosphorus chemistry, an author of over 500 publications on this scientific direction. Prof. Scheer is interested in the chemistry of arsenic and silicon-organo-metallic compounds as well.

Extremely interesting results were obtained by Prof. Scheer in the field of hybrid organo- inorganic materials with group V elements, first of all phosphorus and arsenic, as well in the chemistry of coordination compounds with low-coordinated phosphorus ligands.

Manfred Scheer laid the foundation of supramolecular chemistry of organometallic skeleton structures with cyclopentaphosphadienid ligands and other multiple-deck compositions with ferrocene-like structures.

Scheer's indisputable achievement is the

synthesis of two- and three-dimensional coordination polymer structures with phosphorus ligands.

The most interesting are phospho-carbo-containing frame super-structures with geometry of a spheroidal fullerene type, where pentaphosphaferrocen blocks are associated around carborane playing a role of "guest" molecule. Structure of one of these "super-molecules" corresponds to icosahedral fullerene consisting of 80 carbon atoms.





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АКАДЕМИК  
АЛЕКСАНДР  
ЕРМИНИНГЕЛЬДОВИЧ  
АРБУЗОВ  
1877-1968



“The twentieth century is the Arbuzovs age  
in the history of Kazan Chemistry School”  
*Academician Alexander Konovalov*

“For all chemists over the world this award  
will be associated with Kazan and Kazan  
Chemical School”  
*Professor Louis Quin*

“Needless to say, I shall keep  
as a fantastic souvenir the warm  
hospitality of your city”  
*Professor Francois Mathey*