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SUPPLEMENTARY MATERIAL TO  
**Belgrade School of Electrochemistry**

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ACADEMICIAN ALEKSANDAR DESPIĆ (1927–2005)



Aleksandar Despić was one of the most important Serbian scientists in the second half of the 20<sup>th</sup> century and probably the most important electrochemist in the Central and Eastern Europe of that time. He is the most distinguished founder of the Belgrade School of Electrochemistry. He graduated from high school in his native Belgrade in 1945 and completed his studies at the Faculty of Technology in 1951. The last two years of his studies, he worked as a demonstrator at the Department of Physical Chemistry and Electrochemistry, under his professor Panta Tutundžić and as a scholarship holder at the same Department, in 1953, he was elected assistant.

A turning point in his scientific career was probably the scholarship he received in the autumn of 1953 from the British Council, for improvement under Professor John O'Mara Bockris at the Imperial College of Science and Technology in London. However, due to a confluence of circumstances, that cooperation didn't start until four years later, and not in London but at the University of Pennsylvania in Philadelphia. Since Bockris received an invitation from USA, his colleague G. J. Hills took him in his team. In London, Despić received his PhD in 1955 at the London University and thanks to a recommendation by Professor Hills, he became a senior scientific associate to professor Bockris when he was putting together his first research team at the University of Pennsylvania. That is how in autumn of 1957, Despić found himself at the centre of electrochemistry, and during his stay in the USA, he devoted most of his time to the studies of elec-

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trochemical kinetics, and especially metal deposition and dissolution reaction processes. Over time, Bockris' laboratory became one of the two most distinguished laboratories in the world, next to the laboratory of Alexander Naumovich Frumkin in Moscow, and Aleksandar Despić has also made not small contribution to that.

After returning from the USA in 1959, Despić continued his work at the Faculty of Technology where he soon became an assistant professor (1959), associate professor (1964) and full professor (1971). For a long time, he has held classes in numerous subjects for undergraduate and postgraduate students, such as Physical Chemistry, Colloid Chemistry, Chemical Kinetics, Kinetics of Electrode Processes, *etc.* He was a mentor for 71 graduate theses, 38 magistral theses and 16 doctoral theses. With his associates Dragutin Dražić and Ozra Tatić Janić, he wrote an exceptional textbook *Basis of Electrochemistry*, which is still as current as it was almost half a century ago when it was created. He was elected corresponding member of the Serbian Academy of Sciences and Arts in 1965, and a regular member in 1976. From 1992 he was a member of the European Academy for Surface Technologies, for a number of years, a national representative at the International Society of Electrochemistry (ISE), and from 1977 to 1979 its Vice-President; he was the President of Serbian Chemical Society from 1973 to 1977 and in 1978, he was elected its Honorary President. Scientific and research body of work of Aleksandar Despić (he published 183 scientific and 32 professional articles, he is a (co-) author of 18 studies, 27 patents and 18 textbooks and monographies), as well as his entire contribution to the scientific and professional organisations are impressive (more information about this, as well as his entire life, can be found in the book *Famous Serbian Chemists (Znameniti srpski hemičari)*<sup>2</sup>). However, he is also remembered for his social and organisational engagement, first of all, in the area of science and promotion of science, as well as general social issues. We should just mention that he is one of the founders and directors of the Centre for Electrochemistry and Centre for Multi-disciplinary Studies. However, his most significant contribution in this field must be the establishment of the Museum of Science and Technology in 1989, where he served as its first Director until 1999. In early 1980s, he also initiated establishment of the Foundation for Young Talents.

During the hard times of the break-up of Yugoslavia, with his social engagements, most of all through SASA, where he served as the Vice-president (1981–94) and President (1995–99) in those years, he strived to contribute to finding the most comprehensive solutions for the complex circumstances in the country.

At the end of his life, carefully and thoroughly, like in everything he did in his life, he took care of his legacy. In his testament titled *Bequest*, he distributed all of his property – his books with dedications he left to the Library of SASA and the rest to the Library of the University of Banjaluka, and partly to the

schools in Republika Srpska; his written legacy he bequeathed to the Archive of SASA. With his Bequest, he also established Foundation of Zorica and Aleksandar Despić, with headquarters at the Museum of Science and Technology, to which he also bequeathed his apartment and summerhouse. The aim of the Foundation is to help procurement of objects, production of models and replicas, purchase of books, magazines, films, *etc.*, all of the things that shall contribute to the popularisation of science and technology through the Museum's activities.

ACADEMICIAN DRAGUTIN DRAŽIĆ (1930–2008)



Together with Aleksandar Despić, which was his closest collaborator and friend, he is the founder of the Belgrade School of Electrochemistry. Right after graduation at the Faculty of Technology in Belgrade in 1956, he was elected assistant at the Department of Physical Chemistry and Electrochemistry at the Faculty, where he spent his entire working life. There, he also defended his PhD thesis in 1965, he was elected full professor in 1978 and on two occasions, he was the Head of the Department (1981–1984 and 1987–1995). After Aleksandar Despić, he also spent two years with Professor John O'Mara Bockris at the University of Pennsylvania, from 1956 to 1961.

At the Faculty of Technology, later Faculty of Technology and Metallurgy, he held classes for undergraduate and postgraduate students in several subjects (Physical Chemistry, Corrosion, Electrochemical Kinetics, Electrochemical Double Layer and Adsorption). His work as an educator is best described not by the number of graduate (44), magisterial (25) and doctoral (11) theses defended under his mentorship, but rather the successful careers of his students.

Since the foundation of the Department (later Centre) for Electrochemistry at the Institute for Chemistry, Technology and Metallurgy in 1961, for the next 40 years, he worked on scientific research and from the mid-1970s, he was the Head of the Department. The most important areas of his research are kinetics of electrode processes, electrochemical processes of deposition, dissolution and corrosion and corrosion protection using organic and inorganic coating and electrochemical energy sources. Body of work that originated from his research is impressive: 9 textbooks and monographies; 193 published articles, of which 135 in international journals; 15 patents; 48 articles published in Proceedings and 226 announcements and lectures. He participated in the realisation of 9 national and 5 international projects, of which 11 were managed by him.

Professor Dražić has been a member of numerous international associations and their boards for a number of years. From 1981 to 1991, he was a member of

Electrochemistry Commission of the International Union of Pure and Applied Chemistry (IUPAC), from 1989 to 1999, a member of the Task force for Electrical Engineering of the European Federation of Chemical Engineers (EFCE), and from 1992 to 1994, Vice-president of the International Society of Electrochemistry (ISE). His contribution to work and development of Serbian Chemical Society, where he served as the President from 1981 to 1985, is especially important, and even more so, his contribution to the improvement of the quality and importance of its *Journal of the Serbian Chemical Society*, whose editor-in-chief he was for more than twenty years. Thanks to him, this was perhaps the first journal from this region that made its way to the Science Citation Index (SCI) list.

He was elected corresponding member of the Serbian Academy of Sciences and Arts in 1983, and regular member in 1991.

ACADEMICIAN MILENKO ŠUŠIĆ (1925–2005)



One year after graduation at the Faculty of Natural and Mathematical Sciences (PMF) in Belgrade, in 1951 he began working at the Vinča Institute as a researcher under the mentorship of Pavle Savić. That was the time of the development of nuclear energy program in the former Yugoslavia and he published his first articles on the subject of introduction of polarographic method for determination of uranium content in ore. He defended his doctoral thesis in 1955 and already the following year, he was elected assistant professor at the Department of Physical Chemistry at the Faculty of Natural and Mathematical Sciences in Belgrade (PMF), where he held classes in electrochemistry and chemical thermodynamics. From 1958 to 1959, he was at the Nuclear Centre Argonne National Laboratory, USA, working on the issues of separation of fission products. Together with Ana Savić, in 1967, he translated a capital textbook by S. Glasstone, *Textbook of Physical Chemistry* (Van Nostrand Company, 1946), which has been used in the former Yugoslavia for decades. He is also the author of two important textbooks: *Electrochemistry* (1970) and *Introduction to Electrochemistry and Electrochemical Analysis* (1980).

From 1972 to 1975, he managed the project of improving the production of tantalum capacitors with electrolytic application of oxide dielectric layer, for *Avala* factory of the Electronics Industry Niš, which gained great savings in the loss of tantalum. In his research, as well as his teaching, he introduced areas that were new in the world at the time: electrochemistry in molten salts and electro-

chemistry of solid electrolytes, in which, under the influence of Panta Tutudžić, study of electrical conductivity and electroanalysis has taken the primacy.

Large part of professor Šušić's scientific work consists of research of impregnated zeolites as solid electrolytes. He managed a number of national research projects on the subject of physical-chemical processes in the technology of modern materials, in the last decade on the previous century, with emphasis on alloys for adsorption of hydrogen and hydrogen energetics. Under his mentorship, 24 doctoral theses were defended, he published 230 scientific publications, had almost 300 announcements at scientific gatherings and he is the co-author of 3 patents.

He was elected corresponding member of the Serbian Academy of Sciences and Arts in 1974, and regular member in 1985.

#### ACADEMICIAN RADOSLAV ADŽIĆ (1942–)



After completing his graduate and magisterial studies, in 1974, he defended his PhD thesis at the Faculty of Technology and Metallurgy at the University of Belgrade, which was, at the time, according to the words of Junliang Zhang and Gregory Jerkiewicz in the introduction to the edition of journal *Electrocatalysis* 3(3-4) (2012) 161, which they edited and which was dedicated to the 70<sup>th</sup> birthday of Ratko Adžić, “internationally acknowledged for its exceptional education in the field of electrochemical sciences”. During his work on his PhD thesis and after that, Adžić travelled several times to the Case Western Reserve University in Cleveland, USA, where he collaborated with Ernest Yeager. During the following almost twenty years, up until he left for USA in 1992, at the Institute for Electrochemistry at the ICTM, where he served as director for several years, he led a group of researchers that intensively worked on electrocatalysis. They have demonstrated that ultrathin metal layers deposited on potentials more negative than equilibrium have unique electrocatalytic qualities according to a series of electrochemical reactions, especially those important for science and technology of fuel cells. This group was also the first in the world to demonstrate the impact of density and orientation of platinum and gold monocrystal ladder on the kinetics of formic acid and methanol oxidation. One of the most important results in that period was publication of the general scheme of oxygen reduction reaction, which, among other things, enabled explanation of the most complex results of research on the rotating ring-disk electrode. In the 1980s and 1990s, he worked at the Centre for Multidisciplinary Studies as an assistant professor, associate and full professor.

After coming to Brookhaven National Laboratory, USA, in 1992, where he now holds the title of Senior Scientist Emeritus and Adjunct Professor of the Stony Brook University, for ten years, he worked on the study of surface electrochemistry, through detailed structural studies of metal monolayers and halogenides adsorbed on them, using techniques based on synchrotron radiation. The team he managed succeeded in establishing the structure of active places for certain reactions *in operando*. During the period 2001–2015, the team discovered and developed a new concept of platinum monolayer catalyser, which, apart from significantly improved catalytic characteristics, also has a significantly greater stability and smaller price compared to the standard ones. Practical application of this kind of catalysers could have a great impact on the further development of power systems, by eliminating high price of platinum as the main limitation of the wide application of fuel cells.

So far, Radoslav Adžić has published over 300 scientific articles, cited over 30,000 times, with *h* index of 84. He was elected corresponding member of the Serbian Academy of Sciences and Arts in 1994, foreign member of the Academy of Engineering Sciences of Serbia in 2017 and since 2018, he has been a member of the International Academy of Electrochemical Energy Science. He was awarded numerous awards and recognitions, including Belgrade October Award (1983); Medal of the Serbian Chemical Society (1997); Fellow of the Electrochemical Society, (2005); US Department of Energy's Hydrogen Program R&D Award (2008 и 2012); Inventor of the Year, Battelle Memorial Institute (2005 и 2011), Fellow International Society of Electrochemistry (2012); Thomson Reuters Web of Science: Highly cited researcher (2016), *etc.*

#### ACADEMICIAN SLAVKO MENTUS (1946–)



After graduating at the Department of Physical Chemistry at the Faculty of Natural and Mathematical Sciences in Belgrade in 1969, he was elected assistant at the same Department where in 1975, under the mentorship of Milenko Šušić, he defended his doctoral thesis on the relationship between electrical conductivity, viscosity and molar volume of high-temperature liquids. Within his thesis, he published an equation as a linear manner of connecting these three quantities. In cooperation with his mentor, over the next few years, he worked on the study of conductivity, kinetics of electrode processes in systems with electrolytes, aprotic organic electrolytes and kinetics of hydration of metals and alloys from aqueous solutions. Since 1994, he has been managing classes of electrochemistry at the Faculty of Phys-

ical Chemistry for undergraduate and postgraduate students. He initiated research of electrochemistry of redox polymers and DFT method of analysis of metal/electrolyte boundary, which has been successfully continued by his PhD candidates and later associates. By the start of this century, he managed a national project on the subject of physical-chemical characteristics of materials for electrochemical conversion of energy, and then also the project *Lithium-ion batteries and fuel cells*. Within this research, apart from electrode materials for standard Li-ion batteries, numerous other materials for intercalation of alkaline and other ions from water sources were also studied. During the period 2015–2018, with partners from the Institute of Chemistry in Ljubljana, he led an international project on the subject of stability of electrocatalysts for fuel cells.

He is the author of two textbooks: *Selected Methods for Physical-Chemical Analysis* (1993) and *Electrochemistry*, which were and are still being used by numerous generations of students at the Faculty for Physical Chemistry. He published 193 scientific papers, has more than 200 published announcements from scientific gatherings, and his patent P-1034/91 on artificial induction of crystallisation of atmospheric water is used for protection against hail in Serbia. He managed work on over 100 graduate and over 40 magistral and doctoral theses. He is a member of the Serbian Chemical Society, Association of Physical Chemists of Serbia, Yugoslav Association for Materials Research and International Society of Electrochemistry.

He was elected corresponding member of the Serbian Academy of Sciences and Arts in 2009, and regular member in 2015.

NENAD MARKOVIĆ (1953–)



Nenad M. Marković graduated at the Faculty of Technology and Metallurgy (1977), and obtained his magisterial (1982) and doctoral degree (1984) at the Centre for Multidisciplinary Studies, at the Energy Conversion Department. He learned electrochemistry from the best professors: Aleksandar Despić, Dragutin Dražić and Radoslav Adžić. He did part of his dissertation at the laboratory of prof. Ernest Yeager, at the Case Western Reserve University, in Cleveland, USA. He began his University career in 1978 as a scientific associate at the Institute for electrochemistry. As a young PhD graduate, in 1985 he became a manager of a group for surface electrochemistry and he intensively cooperated with Radoslav Adžić on research of electrochemical catalysts, especially monocrystal surfaces and ad-atom modified surfaces, deposited at potentials lower than the equilibrium. In early 1990s, when

the future crisis in Yugoslavia began to loom on the horizon, he went to Lawrence Berkeley National Laboratory in California, where for the next fourteen years he continued the research he had begun in Belgrade. In mid-2005, he transferred to Argonne National Laboratory, Material Sciences Division, where he is still working as a leading scientist of the Joint Centre for Energy Storage Research.

His main research interest is understanding surface processes on charged boundary of metal-solution phases. Using various *ex situ* and *in situ* surface sensitive spectroscopic and microscopic techniques, in combination with vibrational spectroscopy and classic electrochemical methods, he established relations between microscopic surface structure and macroscopic speed of (electro)chemical reactions. His research largely contributed to understanding of metal nanoparticle activities in energy conversion and storage systems and establishment of the relationship between the speed of reaction, selectivity and stability of catalyst depending on the dimensions of metal catalyst particles.

He is the author of more than 260 articles in the field of electrocatalysis and surface electrochemistry, cited over 38,500 times, with *h*-index 93. He managed 6 projects of development of electrochemical energy conversion and storage, funded by the United States Department of Energy, but he also collaborated with several great automobile companies on the development of power drive for electric cars (GM, Toyota, Nissan, Honda, BMW). Out of his numerous awards and prizes, we should mention Fellow of the International Society of Electrochemistry 2011 and Faraday Medal Award in 2013, awarded by Electrochemical Royal Society.