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Obituary

Dr. Igor Dvornik (1923–2010)

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Igor Dvornik passed away in Zagreb on the 21st of August, 2010 in his 88th year, two months since the demise of his life-long companion Vera. Igor Dvornik was born on the 9th of May, 1923 in Split. He graduated from the Department of Chemical Technology of the Technical Faculty, University of Zagreb in 1951 with the thesis on the subject of colloid chemistry in bauxite processing. Between 1951 and 1953 he was employed at the Institute for Light Metals in Zagreb, where he studied coking of tar resins. Then he took job in the coke factory in Lukavac, Bosnia and Herzegovina. He came to the Ruđer Bošković Institute in 1957 where he established the Radiation Chemistry Laboratory which he headed until his retirement in 1985. He took his Ph.D. in chemistry from the Faculty of Science in 1965.

Although he did not belong to the first generation of employees of the Ruđer Bošković Institute, his actions and attitudes made lasting impacts on the Institute and science in Croatia. His establishing of a new scientific discipline on the one hand, and his understanding of the role of science in a small country on the other hand, have continued to affect both the developments in other branches of scientific research in Croatia, as well as subsequent discussions of science policy.

The history of the foundation of the Ruđer Bošković Institute in 1950, as told on several occasions by its founder Professor Ivan Supek, contains the catchy detail of the considerable freedom given to him in the establishing of the new Institute. Eight years later, as he joined the Institute, Dvornik was given a similar freedom of choice by Professors Supek and Težak. Considering his previous research experience in colloid chemistry, he was offered either to join Težak's group, which was budding at the time into what will become known as the Zagreb School of colloid chemistry, or to propose his own field of future work. After several months of studying the Institute research activities, discussions with colleagues, browsing through journals, monitoring international developments and following the moves of the Federal Nuclear Energy Commission (FNEC), Dvornik decided to break new ground. This decision testifies of his inclination to pursue his own ways and of his self reliance. In the report dated 5th of July, 1958 he proposed that a strong irradiation source be installed and a radiation chemistry labora-

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tory be established in the Institute. These propositions were met with approval of both the Institute authorities and the FNEC.

The same document announced that the projects of the new laboratory will pursue problems which are both scientifically relevant and capable of contributing to the solutions of practical problems. The dichotomy of basic and applied research united under the same leadership bespeaks of Dvornik's sense of social responsibility of science, but it will also remain an apple of dissent between him and all those within and without the Institute who prefered to avoid any practical consequences of their scientific research.

The nuclear orientation of the Ruđer Bošković Institute was evident from the beginning. Its establishing was motivated by the contemporary striving to control atomic energy for peaceful applications on the one hand, but also by the desire to serve military purposes on the other hand. Whether ambitions to develop nuclear weaponry have ever been seriously considered by the state top leadership remains obscured, but the fact is that a considerable research effort in the Institute went into radiobiology. Only »civil« part of it is visible today in Annual Reports and open publications, but it is a known fact that a certain number of staff were employed directly on army contracts.

One of these contracts has been dealing with the development of a radiological emergency dosimeter. Several working solutions have been devised by that time in various countries, all based on the radiolysis of two--phase systems consisting of aqueous and organic phase, the response being based on radiation induced chain dehalogenation reactions in the organic phase. While providing a high sensitivity, which is desirable, chain reaction was at the same time also responsible for poor reproducibility and dose rate dependence of the response, which was, of course, undesirable. Dvornik was also involved in the development of a genuinely domestic version of an accident dosimeter. His original idea to improve the reproducibility and achieve independence of dose rate at the expense of sensitivity was based on sacrificing chain reactions, which was achieved by the elimination of two – phase systems and transition to a homogeneous solution. This idea was substantiated by experiments but has remained dormant until new geopolitical circumstances made it relevant again.

Over the next ten years Dvornik was busy building the laboratory and several irradiation sources. Aspiring to unite scientific and practical interests, as announced in the document proposing the establishment of the laboratory, one field of research which promised a happy union of these endeavours was physico-chemical effects of ionizing radiations in polymeric systems. Especially marked effects, namely, could be expected in systems consisting either of very large molecules and /or in systems undergoing chain reactions, and polymeric systems fulfilled both criteria. This choice was also fitting the currently announced interest of Croatia for the development of petrochemical industry. As there has been no significant research activities in that field in Croatia, Dvornik sought international co-operation. The co-operation with the Institute of Plastics Industry in Budapest and the prestigeous Institute of Chemical Physics in Moscow under the aegis of the International Atomic Energy Agency were initiated in 1963. Within that co-operation unique instruments specially designed for radiation – chemical studies of polymerization in an irradiation field were acquired: a Calvet microcalorimeter and a universal ralaxation spectrometer

Besides designing a closed-type source for his own laboratory, he designed an irradiation source for mutation studies in the Genetics Department of the Faculty of Agriculture, but his main edifice was the large panoramic cobalt-60 gamma irradiation facility. He demonstrated not only his engineering skills in designing it, but also his forward-looking thinking in designing radiation shielding of the irradiation vault and access maze, so as to enable the housing of a much stronger source than originally installed. More than twenty years will pass before that source will be loaded with radioactive cobalt-60 to its full capacity.

As he set out to calibrate the available radiation fields he was confronted with the limited applicability of current dosimetry systems, notably of the Fricke dosimeter. At that time there has been no commercially available dosimetry system to do the job but numerous solutions have been proposed in the literature. Dvornik's experience with chemical dosimetry in the development of a personal accident dosimetry system helped him formulate a novel chemical dosimetry system suitable for high dose applications. The novel system made away from the then prevailing aqueous systems using an eponymous ethanol chlorobenzene solution. As it turned out in numerous later investigations, its response was independent of dose, dose rate, LET and radiation energy over a broad range of these variables, was insensitive to impurities and environmental conditions, and a number of analytical techniques could be used for the readout. Thanks to its simplicity and reliability the system gained the popularity with the users all over the world, especially when coupled with the ingenious readout method applied by the Hungarian scientists. It has been accepted as an ISO/ASTM standard since 1993, described in all handbooks on high dose dosimetry, included in the coresponding ICRU Report, that »Bible of dosimetry«, and used in more than 30 countries.

Considerable time and effort were spent on dosimetric mapping of available radiation fields. As soon as radiation sources were properly calibrated the unconditional access to other researchers interested in various aspects of radiation research was opened. Permissions to use irradiation services in his laboratory were granted without ever requesting a coauthorship from a colleague. In doing so Dvornik not only fulfilled the promise given in the proposal for the establishment of the laboratory, but also demonstrated his unlimited unselfishness towards his fellow scientists. Considerable body of scientific results

of radiation studies in solid state physics, biophysics and radiobiology achieved in the Institute are due to their authors' free access to irradiation facilities built and maintained by Dvornik and associates.

Dvornik was one of the pioneers of radiation chemistry who early recognized the role of nonthermal electrons in the radiolysis of concentrated solutions. Extensive literature survey he made for his PhD in 1965 and his brilliant intuition helped him understand the relationship between gas-phase electron attachment and liquid phase electron scavenging four years before dry electron reactions were introduced into a new model for radiolysis of water. When Dvornik finally published his ideas in 1970, it was still a pioneering work because there have been not more than two laboratories in the world ready to accept them.

The geopolitical circumstances to mobilize Dvornik to revisit his earlier work in personal dosimetry, which will strongly determine the future of his laboratory and himself personally, were brought about by the Soviet occupation of Czechoslovakia in 1968. The response of the Yugoslavian leadership to this event was the inauguration of a defensive doctrine called all-national defense and societal self-protection, whereby even the possibility of the deployment of nuclear weapons was not entirely excluded. Any realistic anticipation of acting under a nuclear attack scenario called for the ability of isolated military units and civil authorities to act with a high degree of autonomy in taking vital decisions; decentralization and self reliance were felt to be critical for survival. To make it technically viable, a personal dosimetry system compatible with rather harsh requirements had to be introduced. Dvornik revived his earlier concept based on a single phase accident dosimeter and supplied it with a corresponding simple visual readout device, colorimetric comparator. The system met the most stringent requirements: it was sturdy, simple to use and independent of any external power source. It was demonstrably functional in anybody's hands without much prior training and perfectly matched current defense philosophy. At the same time it was several times cheaper than any competing foreign system.

For his solution of the personal accident chemical dosimetry system Dvornik was awarded Nikola Tesla State Award for Technical Achievement in 1970 and the same year the massive production of the dosimeters and readers was organized in the Institute. For almost twenty years nearly two million dosimeters and thousands of readers were manufactured and distributed to fill the needs of the army and civil defense. Dvornik maintained that the price should cover not only the bare production costs but that it must make for both past and future developments and managed to persuade the authorities to accept it. Indeed, the revenue was significant, enabling the investments into the scientific assets: staff, space and equipment.

Dvornik soon felt the responsibility to provide users not only with dosimeters, but also with basic knowledge of radiation protection. The laboratory took over the education of decision makers and ordinary users of radiation protection under a hypothetical emergency. The credibility of the educators required working knowledge of radiation protection. Therefore Dvornik added radiation protection to the spectrum of his interests and extended the scope of the laboratory adding dosimetry to its name, which was the more logical as the first nuclear power plant in the country was nearing its completion. Dvornik became interested also in radiation safety, which all lead to his appointment to the resurrected Nuclear Energy Commission. He introduced a modern dosimetric technique based on thermoluminescence into his laboratory, which made possible quantitative dosimetric monitoring of personnel, patients and space involved in medical uses of radiation, as well as environmental monitoring. This formed the basis for the acceptance of well informed radiation protection practices.

The possibility of deployment of tactical nuclear weapons with an enhanced neutron component, the so-called neutron bomb, represented not only a global threat during the Cold War, but dosimetry of mixed gamma and neutron radiation fields was also a challenging task for dosimetry. Dvornik recruited his many personal contacts to organize experiments at well calibrated neutron beams to determine the response of the personal accident dosimeter to neutrons of various energies. In a serendipitous outcome, the dosimeter was shown to be nearly tissue-equivalent with the same response to the same dose of gamma rays and neutrons. To the present day it remains the only dosimetry system with these unique characteristics.

Albeit identifying himself mostly with the accident dosimetry system, Dvornik encouraged other initiatives combining scientific and applied scopes, which continued to develop in the laboratory after his retirement. One of them concerns studies related to the uses of biocidal effect of irradiation, including radiation sterilization, food irradiation etc. To enable research and development in this area he undertook the reconstruction of the panoramic irradiation facility transforming it into a pilot plant-size facility with the strongest gamma radiation source in the region. He also built the space adequate for housing of a donated electron linear accelerator suitable for pulse radiolysis and radiation processing. Both actions proved successful: the panoramic irradiation facility has been offering irradiation services for more than 25 years now, and the electron linac has just been demonstrated operational after the re-assemblage at our location and an extensive reconstruction.

Dvornik was an unrestful and an independent mind, not easily impresssed with the conventional thinking nor with the established methods, always in quest for his own ways and means. Once accepted by him, he was loyal to people and persistent in the realization of ideas. He would passionately defend his positions, scientific and political, yet not forcing them upon anyone. A modest person himself, he could not stand only arrogance. He had an enormous capacity for other people's problems

and would usually be keen to find a solution for them before the end of a conversation. Dvornik will be remembered by his unfaltering optimism. It helped him survive at the head of the production of the personal accident dosimetry system for years in spite of many hurdles he was meeting, both within and without the Institute, taking those hurdles as challenges to be overcome rather than as a reason for dispair.

Dvornik was fluent in English, French, German, Italian and Russian, and enjoyed to communicate with people, preferably in their mother tongue. He enjoyed attending scientific meetings as the most stimulative and effective way of exchanging ideas and opinions. He would assemble a small informal group and discuss questions of interest until late after the sessions. He made lasting friendships on many of these occasions. As much as he enjoyed verbal communication, though, he felt grave responsibility towards the written word. Only an urge to meet a deadline for a conference was a driving force strong enough to make him finalize his ideas in a written form.

It has been my privilege to have had a personal relationship with Igor Dvornik. I enjoyed his guidance in my early days and his friendship later on. Igor and Vera are survived by two sons, Srđan and Siniša and three granddaughters, Hana, Maša and Lada, who inherit their humanistic and intellectual ideals and values.