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Review

A Brief Review of Chromatography in Croatia

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Abstract: Although the Republic of Croatia is a relatively small country geographically, it can boast numerous scientists who have left indelible marks in various scientific fields. However, this paper is exclusively about chromatography as one of the most important analytical techniques of our time. The development of chromatography in the Republic of Croatia and the role that three institutions have played in it—the Faculty of Chemical Engineering and Technology of the University of Zagreb, the Croatian Society of Chemical Engineers, and the Central European Group for Separation Sciences—will be briefly discussed.

Keywords: chromatography; history; Croatia

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When discussing the development of chromatography in the Republic of Croatia, it is logical to start with the name of Dr. Srećko Turina [1] (Figure 1). This visionary of chromatography is also considered a pioneer of chromatography in the Republic of Croatia [2].

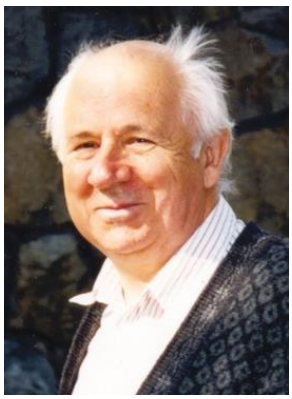

Figure 1. Dr. Srećko Turina.

Srećko Turina received his PhD from the Faculty of Technology in Zagreb (now the Faculty of Chemical Engineering and Technology) in 1959 with a thesis in the field of gas chromatography [1]. Afterwards, he continued his research activities in the field of chromatography. Although his research was conducted with limited resources and at a time when the scientific literature was not nearly as accessible as it is today, Dr. Turina's ingenuity successfully overcame these limitations. Therefore, Dr. Turina published the results of his research in the most prestigious scientific journals of his time. Based on the experience gained through experimental work, Dr. Turina provided his statistical-kinetic interpretation of the transition from the stationary to the mobile phase by overcoming the energy barrier, thus perfecting the existing simple models for interpreting the chromatographic process and applying them to the real processes of thin-layer chromatography [3]. The importance of Dr. Turina's interpretation is reflected in the fact that Friedrich Geiss, one of the most

important chromatography theorists of his time, included it in his book, *Fundamentals of Thin Layer Chromatography: Planar Chromatography* (Chromatographic methods) [4].

In 1984, Dr. Turina published the book Tankoslojna kromatografija (Thin Layer Chromatography) [5], the first book on chromatography published in the Republic of Croatia. Dr. Turina willingly shared his extensive chromatographic knowledge by giving courses on Special Methods of Chemical Analysis (at the Faculty of Chemical Engineering and Technology of the University of Zagreb; FCET), Chromatography (at FCET), and Chromatographic Methods of Analysis (at the Faculty of Science of the University of Zagreb) [1]. Under the supervision of Dr. Turina and with the mentorship of Prof. Vjera Marjanović Krajovan [6], the young scientist Marija Kaštelan-Macan defended the first master's thesis [7] and, subsequently, the first dissertation [8] in the field of chromatography in Croatia. Dr. Turina's collaboration with Marija Kaštelan-Macan lasted for many years and later led to the publication of another chromatography book, Plošna kromatografija (Planar Chromatography) [9].

In addition, Dr. Turina was a very active member of the Croatian Society of Chemical Engineers (CSCE). This society, founded in 1912 [10], brings together chemists, chemical engineers, and chemical technologists to improve chemical engineering and related professions in the Republic of Croatia. Accordingly, it has played an important role in the promotion and development of chromatography in Croatia. A group of chromatographers, including Štefica Cerjan Stefanović, Vlasta Drevenkar, Blaženka Jurišić, Marica Medić-Šarić, Mira Petrović, Nikola Šegudović, Vladimir Švob, and Srećko Turina, as part of CSCE's Section of Chromatography, published the handbook Kromatografsko nazivlje [11] in 1999, which was a translation of the recommendations of the International Union of Pure and Applied Chemistry (IUPAC): Nomenclature for Chromatography [12]. Section of Chromatography, which has been an active part of CSCE almost since the beginning of chromatographic practice in Croatia, promotes the dissemination of knowledge about separation sciences in the Republic of Croatia by inviting top-class lecturers from all over the world and promoting continuous education. To achieve its goals, Section collaborates with a number of international associations such as the European Society for Separation Science (EuSSS) and the Central European Group for Separation Sciences (CEGSS).

Of the 25 International Symposia on Separation Sciences (ISSS), six symposia have been held in Croatia to date (all organized by CSCE). The origin of the ISSS symposium can be found in the national GC meetings held in Zagreb, Croatia, since 1967. Based on these meetings, the CEGSS was founded in 1998. Dr. Nikola Šegudović (Figure 2), a member of the CSCE and its Section of Chromatography, was one of the initiators of the CEGSS [13] and its permanent member. In 2006, at the twelfth ISSS Symposium in Lipica, Slovenia, Dr. Šegudović was proposed as the first Secretary of the CEGSS [14].

Figure 2. Dr. Nikola Šegudović.

The 2nd ISSS was the first to be held in Croatia, in Opatija in 1992, and the president of the organizing committee was Dr. Srećko Turina. Only four years later, in 1996, Opatija hosted another ISSS symposium (ISSS), and the president of the organizing committee was

Dr. Nikola Šegudović. Until 2008, three more ISSS symposia were held in Croatia under the leadership of Dr. Nikola Šegudović: 6th ISSS Plitvice 2000, 10th tenth ISSS Opatija 2004, and 14th ISSS Primošten 2008. The years 2011 and 2012 were sad years for Croatian chromatography: in 2011, Dr. Srećko Turina passed away at the age of 80, and in 2012, Dr. Nikola Šegudović also died suddenly at the age of only 66.

In the second half of the 20th century, chromatographers in Croatia were mainly dealing with thin-layer chromatography [15–26]. However, towards the end of the century, the situation began to change. With the development of chromatography in the world, modern chromatographic techniques were increasingly used in Croatia as well [27–34]. In the 1990s, Prof. Štefica Cerjan Stefanović from FCET gathered a small team of scientists who worked intensively on the development of ion-chromatographic methods. The team joined forces with Prof. Nebojša Avdalović from Dionex Coorporation and began a successful collaboration in developing a mathematical model to simulate the response of ion-chromatographic analysis [35–39]. One of the products of this activity was the book Ionska kromatografija (Ion Chromatography) [40] by Tomislav Bolanča and Šime Ukić, published in 2015. In addition, the team continuously promoted chromatography in Croatia and surrounding countries. In 1997, the team began organizing the annual International School of Ion Chromatography (ISIC). The school was intended to bridge the gap between chromatographic theory and everyday practice, and to provide unbiased education based on scientific facts and many years of experience. The first ISIC was held in Zagreb. However, since Dr. Milko Novič from Slovenia decided to participate in the organization of the ISIC schools, the schools were organized to take place one year in Croatia and one year in Slovenia. Later, the school was held only in Croatia and the organizing rhythm has changed from one to two years. Over time, other FCET chromatographers also joined the ISIC organization. Since 2012, the school is no longer focused on ion-chromatography only and has changed its name to the International Chromatography School (ICS). To date, 19 ISIC/ICS schools have taken place, and the high number of participants in the schools speaks to the need for such an event (Figure 3).

Figure 3. 18th International Chromatography School, Zagreb, Croatia, 2018: Professor Joachim Weiss presented new achievements in chromatography to a large audience.

In parallel with the ISIC schools, Prof. Marija Kaštelan-Macan and her team organized courses in thin-layer chromatography (2001) and liquid chromatography (2007) for a number of employees of the pharmaceutical company PLIVA. Prof. Marija Kaštelan-Macan saw a mismatch between the pace of development of modern analytical techniques,

including chromatography, and the design of the corresponding terminology in the Croatian language. This mismatch resulted in the introduction of many foreign words into the Croatian language. Therefore, in 2014, after substantial study, Prof. Kaštelan-Macan published the Encyclopedic Dictionary of Analytical Terminology [41].

After the retirement of Prof. Cerjan Stefanović and Prof. Marija Kaštelan-Macan, Prof. Tomislav Bolanča and Prof. Sandra Babić, respectively, took over the leadership of the teams. These two teams, together with the team of Prof. Marica Medić-Šarić from the Faculty of Pharmacy and Biochemistry of the University of Zagreb, have gradually been involved in the activities of CSCE and its Section of Chromatography. Therefore, after the death of Dr. Šegudović, the CEGSS Committee elected Prof. Tomislav Bolanča as the Croatian representative to the Committee, which is still the case. Prof. Bolanča has continued to intensively promote separation sciences. Through his work in the CEGSS association, he intensified his collaboration with Prof. Bogusław Buszewski from Nicolaus Copernicus University (Toruń, Poland). The collaboration extended not only to the scientific field, but also to education. Namely, numerous FCET students took the opportunity to travel to Toruń for student training, which was an invaluable experience for them.

Prof. Tomislav Bolanča was the chairman of the organizing committee of the last ISSS symposium held in Croatia: the 19th ISSS Poreč 2013 (Figure 4). The topics prepared for the Symposium covered all aspects of chromatography and other separation and detection techniques, including multidimensionality in separation, hyphenations in detection, chemometrics and quality assessment, confirming the cutting-edge power of chromatography and separation techniques. The specificity of the 19th ISSS symposium was that the 14th ICS was held as a special Symposium section. It seems that this symposium has additionally increased the visibility of FCET analytical chemists, leading to more intense collaboration with scientists of other preferences and to the application of chromatography in a wide range of fields: from environmental protection and food analysis to the protection of cultural heritage.

Figure 4. Book of Abstracts from the 19th ISSS symposium, Poreč, Croatia, 2013.

In the period to which this review refers, many other scientists in Croatia were also engaged in chromatography. However, only those events and facts with which the authors were most familiar were mentioned. Therefore, the authors would like to take this opportunity to apologize to those whom they inadvertently omitted from this review. They too have contributed to the development and promotion of chromatography and separation sciences in general, for which they are to be thanked.

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