THE DEVELOPMENT OF CHEMICAL SCIENCE AND CHEMICAL TECHNOLOGY IN THE FIRST HALF OF THE 20th CENTURY IN CROATIA

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Abstract

The beginnings of modern chemical science were connected in Croatia with the reorganization of the University of Zabreb and foundation of the Department of Chemistry at the Faculty of Philosophy in the second half of the 19th century, while the teaching of chemical technology started only after the foundation of the Technical High School (1919), which in 1926 became the Faculty of Technology at the University of Zagreb. Together with specialized lectures in chemical technology scientific research has started in various areas of pure chemistry, and organic and inorganic analysis has undergone a great development at the Faculty of Technology. Special advance has been made in organic chemistry due to the activity of Professor dr. Vladimir Prelog (Nobel Prize for chemistry in 1975) who worked there for seven years until 1941 and whose students later took important professorships in organic chemistry at the University of Zagreb. The 1920s and 1930s, have seen a great development of chemical industry in Croatia like in other parts of Yugoslavia.

The period immediately after the year 1918 when the first united national state of South Slavs was founded is very significant for the development of science and particularly for the progress of technology in Yugoslav countries. Croatia, which had also in the field of science a different historical development than other parts of Yugoslavia, entered this new Yugoslav union with an advanced University in Zagreb having long traditions in the study of natural sciences[3]. Since 1876 the chair of chemistry at the University of Zagreb has provided lectures in chemistry joined with efficient scientific research work. At the end of the 19th century chemistry became a profession on its own right, with its own training schools all over the world. The organisation of chemistry and the dissemination of chemical knowledge have become important activities of chemists.[10]

In spite of the fact that chemical technology gained great importance in the development of industry, agriculture and other activies, at the time of the

establishment of the chair for chemistry at the University of Zagreb, there was no possibility for teaching chemical technology. Simultaneously with the foundation of the first chemical institute in Zagreb (1876) efforts were made to introduce chemical technology teaching. At that time dr. Karel Otokar Čech (1843–1895) discussed in his booklet "Die Chemie an der Kaiser Franz Josefs Universität zu Agram" (Praha 1874, 55p.) the importance of the tuition of chemical technology for the development of industry. Čech competed for the position of the first professor of chemistry at the University of Zagreb but was not chosen. His idea was to establish a close connection between teaching and scientific research work in chemistry with the progress of industry. Čech saw the important role of the education of experts in chemistry and technology and of the richness of the country in raw materials, which were insufficiently utilized at the time, in the development of chemical industry.[22]

The chemical engineer Milutin Barač (1849–1938), another candidate for the professorship of chemistry in 1875 could have been of the same opinion if he had been elected first professor of chemistry. Barač later devoted himself to the oil industry and is known as the founder of the refinery in Rijeka in 1883, which is the oldest of its kind on the territory of Yugoslavia.[26]

It is necessary to mention that the concept of the importance of chemical technology teaching was accepted earlier at the *Lycée* in Belgrade (later since 1905 the University of Belgrade) than at the University of Zagreb. From the year 1863 both chemistry and chemical technology teaching were introduced at the university level in Belgrade.[2] The pattern of technological education and industrial development in Europe differed from one country to the other depending on political and ideological as well as economic circumstances.[9]

In the middle of the 19th century the particular sociopolitical and economic conditions in the country were favourable for the efforts of the contractors' companies in Croatia to start with the manufacturing enterprise in different branches of the manufacturing industry.[12] Trade competition of the more developed countries in the Austro-Hungarian Monarchy made the successful progress of some industrial branches in Croatia impossible as for instance textile industry; but there existed favourable conditions for the progress of wood industry, shipbuilding while the production and processing of cereals, sugar-beet, glass, paper etc. had a special place. In fact the richness and availability of raw materials also promoted the development of the industry.[8]

Chemical industry started to advance also in the second half of the 19th century and in its development the educated chemist-technologist played an essential role.[13] As there were not enough experts in the country, foreign engineers were engaged. A small number of native chemist-technologists were educated at the technical high schools in Vienna, Prague, Graz and Budapest or at the high schools outside the Monarchy. In Croatia only the basic knowledge of chemical technology could be acquired at the newly established

and more modern secondary schools founded after 1853 in Rijeka, Zagreb, Rakovac (near Karlovac), Split and in other towns, where chemistry was taught together with chemical technology. These secondary schools gave their students a good knowledge for engineering studies; particulary the teaching programme of the more modern secondary school in Rakovac which can be considered a type of technical school which was specially suited to prepare for studies at the technical high schools because special emphasis was placed in the teaching programme on compulsory professional and natural history subjects.[20]

The need for the foundation of a technical high school on the Faculty of Technology became urgent in Croatia especially at the end of the 19th century and in the first decades of the 20th century. In the 1880s there were discussions in public and in newspapers about the need of a technical high school in Croatia. The replacement of foreign engineers with experts educated at home was essential for the economic development of the country. There were lively discussions among the members of the "Association of engineers and architects" in Zagreb about the foundation of a Technical High School but their efforts as well as their suggestions to the general assembly in the year 1899 were not realized at that time.[24] Almost in all countries of Europe the scientific and industrial development was rapid in this century, beginning in the years following World War I.[5]

In 1919 in the newly founded Kingdom of Serbs, Croats and Slovenes a number of new faculties were founded with the aim of educating new specialists indispensable for the progress of technology, science, medicine, agriculture, forestry and other branches. At that time the efforts for the foundation of a technical high school were realized successfuly: the Technical High School was founded and it became the Faculty of Technology of the University of Zagreb in 1926. The Faculty of Agriculture, Forestry and Veterinary Science (its real beginning was at the Agricultural college in Križevci founded in 1860) was also founded at the University of Zagreb at that time and pure and applied chemistry were lectured on. A new very remarkable centre for chemistry was developing from the year 1919 at the Faculty of Medicine in Zagreb with well equipped laboratories and a rich library.[23] Although the teaching at the Faculty of Medicine was assigned to medical students, it had a strong and extensive influence on the development of chemistry in Croatia.

It is necessary to mention that in the previous period for more than four decades (from the year 1876) university level chemistry was lectured on only at the Faculty of Philosophy in Zagreb by only one professor, Professor dr. Aleksander Veljkov (Welkow, Velkov) (1847–1878) from the foundation of the chair for chemistry[21] and Professor dr. Gustav Janeček (1848–1929) from the year 1879.[19]

In the year 1919 Zagreb had four new university centres for pure and

applied chemistry. The teaching of chemistry and chemical technology was performed at the Technical High School by a number of professors—experts educated at the University of Zagreb or abroad. This school became a new centre for the development of modern chemical science and chemical technology as well as the centre for the collaboration with chemical industry in Croatia and Yugoslavia. Different institutes were established at the chemical-engineering department such as institutes for analytical, inorganic, organic and physical chemistry as well as institutes for the organic and inorganic technology and metallurgy. The professors of this Department succeeded in theoretical university level teaching of chemistry and chemical technology along with the intense work with students in laboratories and at the same time dealing with scientific research work at a high level, so that some results of their work became known also abroad.[25]

In the Institute for analytical and inorganic chemistry Professor dr. Vladimir Njegovan (1884–1971) devoted himself to analytical research predominantly improving gravimetric methods. Later on he worked together with Vjera Marjanović-Krajovan—the first woman who attained (in 1928) the Ph. D. degree in technological sciences in Croatia (from 1959 appointed professor of analytical chemistry).[6]

Professor Ivan Marek (1863–1936) successfully dealt with elementary analysis at the Institute for organic chemistry and he improved the Liebig's method of elementary analysis by exchanging the gas burner with the electric one; he introduced in this field new techniques without using copper oxide or any other catalyst.[11] Marek's method of elementary analysis aroused great interest among chemists particularly in France. Marek was among the first students who acquired all his knowledge of chemistry in Zagreb, his native town; he studied and took his degree at the Faculty of Philosophy at the University of Zagreb. Based on his long-standing experiments Marek came to the conclusion that no catalyst is necessary in the process of elementary analysis if the temperature is high enough in the short part of the oven where the test substance is burned in excess oxygen.[15] He achieved this by burning the substance in a small test tube which he pushed slowly into the blazing zone of the oven. Marek improved his invention of burning the substance without catalyst by constructing an electrical oven which was used sucessfully abroad. He applied his experience with the new electrical oven for elementary analysis to determine sulphur in organic compounds and later for the determination of nitrogen according the method of Dumas. Marek's system for burning would probably have shown its special advantages if it had been used in microelementary analyses. Marek produced and commercialised in Zagreb the oven and apparatus for elementary analysis. This was at the same time when Pregl's method for microanalysis was accepted and maybe this was the main reason why Marek's ovens were produced and sold only for a short time.

The Russian chemist Professor dr. Ivan Plotnikov (1878–1955) ran the Institute for physics and physical chemistry from 1921. He came to this chair with great experience and remarkable scientific results in the field of photochemistry and contributed to the development of photochemistry in Croatia. Professor dr. Franjo Hanaman (1878–1941) well known as the inventor of the contemporary electric bulb was appointed in 1922 professor of inorganic chemical technology and metallurgy. Before coming to Zagreb Hanaman worked with his colleague dr. A. Just as assistant to Professor G. Vortman in Vienna and they invented the method for preparing thin tungsten filament and so solved the problem of the usage of wolfram, a high-melting metal in the producting of electric light bulbs.[6] The Institute for organic-chemical technology was founded at the Faculty of Technology (in 1929) by Professor dr. Matija Krajčinović (1892–1975) who dealt with different problems from this field, in the first place with the production and use of raw materials (soya, cellulose, starch, tannin etc.). He was the first expert for colours and dyeing in Croatia and stressed this brach of knowledge in his tuition.[25]

The interest for the study of chemistry and chemical technology at the Technical high school, later Faculty of Technology was increasing all the time, which is obvious from number of students steadily increasing from year to year. A very large number of enrolled students, 47 instead of the 15 expected, had at the very beginning caused the lack of equipment and chemicals at the Chemical-engineering department. Part of equipment was brought to this Department from other high schools, faculties and academies in Zagreb. The optical instruments were bought in Vienna in 1920 and the chemicals were also procured abroad.

In spite of insufficiently equipped laboratories and the slow and gradual establishment of chairs at the Department the first ten engineers of chemistry took their degree in 1923. In the period till 1938 altogether 228 engineers of chemistry took their degrees at the Faculty of Technology at the University of Zagreb. (Yearly 13.4 on average; the maximum 19 engineers of chemistry in 1927 and the minimum 10 engineers of chemistry in 1923.)[25] In 1925 the first Ph. D. was earned in the scientific technological field of chemical engineering in Zagreb. In the period till 1938 one to three candidates obtained Ph. D. in a year; altogether 19 Ph. D. degrees were achieved in chemical engineering and chemistry at the Faculty of Technology till 1938.[25] The above mentioned professors of the Technical high school, later the Faculty of Technology contributed a lot to the development of chemistry and chemical technology in Croatia by publishing a large number of scientific and specialized papers as well as university textbooks and manuals in which they recorded modern knowledge of chemical science and chemical technology.

A notable contribution to the development of chemistry in Croatia was from the 1880s made by professors from the Faculty of Philosophy and later

not only by professors from the Faculty of Technology but also by professors from the Faculty of Medicine (Professor dr. Fran Bubanović) and the Faculty of Veterinary Science (Professor dr. Adolf Režek) and from other faculties in Zagreb. Of great importance was the textbook "Chemistry" written by Fran Bubanović (1883–1945) (Zagreb 1930 as well as the post-war edition) in three volumes which was for a long time the only complete university textbook for chemistry in Croatia. Bubanović was a real expert in chemistry (he was a student of J. Hamburger, a physiology chemist from Groningen and also a student of S. Arrhenius, one of the founders of modern physical chemistry) who attached special importance to physical chemistry in the study and understanding of the phenomena in living organisms. With his numerous popular lectures, papers and books about chemistry and biochemistry Bubanović influenced greatly the scientific and wide public interest in Yugoslavia for more than three decades.[14] A very special and remarkable period of the development of chemistry in Croatia, particularly organic chemistry was the time from 1935–1941 when Professor dr. Vladimir Prelog (born in Sarajevo 1906) was teaching at the University of Zagreb. Vladimir Prelog was later, in 1975 awarded the Nobel Prize for chemistry (with J. W. Cornforth).[1]

The participation of Professor Prelog in scientific, university and economic life of his native country exceeds in importance his seven-year activity as a University professor of organic chemistry at the Faculty of Technology in Zagreb. After finishing grammar school in Zagreb Prelog studied chemistry in Prague where he obtained Ph. D. under Professor E. Votoček and learned about the chemistry of natural compounds. From the very beginning of his scientific work Prelog was interested in the problems of the structure of organic molecules and his research work on organic synthesis had an explicit stereochemical character. His later works which are an extension of the synthesis of adamantine, which Prelog synthesized in the 1940s at the University of Zagreb,[17] greatly contributed to the development of stereochemistry by means of methodology and new concepts. In a number of papers published during the time of Professor Prelog's activity in Zagreb, Prelog and his coworkers defined the relative and absolute configuration of quinine[16] by transforming quinine by the process of overhauling to simple optically active compounds. These compounds are similar in configuration to amino acids and sugars, constituents of living cells. Professor Prelog organized in Zagreb the school for organic chemistry and brought organic chemistry to the European level, he worked successfully with young assistants and coworkers and helped the development and progress of chemical and pharmaceutical industry. He influenced the development of the research centre in the factory "Kaštel" which later grew into the Research institute of the factory of pharmaceutical and chemical products "Pliva" in Zagreb. It is worth mentioning that in the period from 1935 to 43 Prelog worked out and

published most of his scientific papers together with his associates in Zagreb and his cooperation with scientists from all over Yugoslavia continued. After leaving Zagreb to become an associate of Professor dr. Lavoslav Ružička in Zürich (1887–1976) [18] (Lavoslav Ružička is of Yugoslav origin too [7] who won the Nobel Prize in Chemistry together with A. Butenandt in 1939 [4]) Vladimir Prelog followed and encouraged the development and progress of organic chemistry and biochemistry.

Conclusion

After the establishment of University-level teaching programme of chemical technology and applied chemistry at the University of Zagreb after 1919 there was a close relation between the development of industry in Croatia and the education of engineers, specialists in chemistry. Chemical engineers educated in Croatia gradually replaced foreign experts in factories and at the same time research and control laboratories were established in factories. Some factories had extremely well equipped chemical laboratories and good relations with different Faculties (especially with the Faculty of Technology of the University of Zagreb). It can be concluded that in the first half of the 20th century the new relationship established between chemical sciences and chemical technology played an important role in the progress of industry in Croatia and Yugoslavia.

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