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Jaroslav Heyrovský and Wiktor Kemula: The Czech and Polish polarography

THE COOPERATION OF THE CZECH AND POLISH scientists may be well documented in the case of polarography, where both of the nations attained significant results at the world scale.

Polarography is an unusually sensible method of electroanalysis in course of which the analysed solution is being electrolysed. One of the electrodes is the mercury dropping electrode to which the rising voltage is gradually and continually laid. From the position and height of the curve current-voltage, the individual element contained in the analysed solution may be specified and its concentration can be established, all that with an extraordinary accuracy. The method of polarography was invented by Jaroslav Heyrovský in 1922. Wiktor Kemula was one of his numerous disciples. Let us have a closer look at the fates of this method as well as at its representatives.

Jaroslav Heyrovský was born in Prague into a family of a university professor in 1890. Wiktor Kemula was born at Izmail, Bessarabia, into a family of Polish patriots in 1902. While Heyrovský studied at the universities in Prague and in London, Kemula studied chemistry and associated sciences at the university of Lwow. Heyrovský attained his PhD degree in 1918 and got a stimulation to study the electrocapillarity of mercury. He devoted his research to this topic for several years, first as the university lecturer and later as the associate professor (since 1920). The above-mentioned invention of the electrolysis with mercury dropping electrode came in February of 1922. Heyrovský was appointed extraordinary professor in physical chemistry at the Prague Charles University in the very same year. Three years later, he and his Japanese disciple M. Shikata constructed an apparatus that automatically recorded (by photographic way) the current-voltage polarization curves. Polarography became the dominant method of research at the Charles University Institute of Physical Chemistry, which was led by Heyrovský, who became Full Professor in 1926. The concern was not merely the application of polarography within the analytical chemistry, but also its scientific grounds.

Kemula meanwhile graduated at the Lwow university and was awarded his PhD title for his thesis concerning the action of the ultra-violet rays on the methane family hydrocarbons. He then became assistant lecturer with Prof. Tolloczki at the Chair of Inorganic Chemistry of the University of Lwow. In the late 1920s, Kemula obtained a scholarship granted by the Polish National Research Fund, which qualified him for internships abroad, namely with Prof. Heyrovský in Prague (1929–1930) and with Professors Weigert and Debye in Leipzig (1930–1931). During his Prague attachment, which was to become of decision for his future scientific development, Kemula elaborated two polarographic studies under the auspices of the Charles University Institute of Physical Chemistry. These were published in the Collection of Czechoslovak Chemical Communications, a journal founded by J. Heyrovský and E. Votoček in 1929. These studies provided grounds for his habilitation at the University of Lwow, which took place in 1932. His theses concerned the overvoltage of mercury precipitation from the solutions of mercurous salts. Kemula's Lwow career was quite swift as he was appointed Extraordinary Professor in 1936 and Full Professor in 1939. Due to Kemula's efforts, the polarography method spread throughout the entire Poland in the 1930s. It may be of interest that Heyrovský's first Polish disciple, M. Dobryszycski (1903–?), who studied in Prague and obtained his PhD title in 1930 for his thesis concerning the deposition of zinc and cobalt from ammoniacal solutions at the mercury dropping electrode, did not remain faithful to the polarographic research. Kemula was a different case. He engaged both his students and his collaborators, in particular M. Michalski, for polarographic research at the University of Lwow. Apart from that, Kemula spoke at the International Union for Pure and Applied Chemistry Congresses held in Madrid (1934) and Rome (1938) even before the WW

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II. One single letter handwritten in Czech by Kemula and addressed to Heyrovský has been preserved from the pre-war period. Kemula writes about his present-time work at the University of Lwow and mentions his doubts whether to publish openly a critical article on one Czech study presented in the *Collection* journal, as he would not like to impair the nascent reputation of Heyrovský's and Votoček's journal (*Collection of Czechoslovak Chemical Communication*).

Meanwhile in Prague, Heyrovský with his students, assistants and guest visitors from abroad formulates the theoretical grounds of polarography. The important boundary mark was the derivation of an equation for electrolytic current directed by the speed of diffusion of electro-active species to the surface of dropping mercury electrode. The relation had been named, after the author, Ilkovich's equation. It may be of interest that the first impulse to the mentioned issue came from Kemula. Heyrovský's prominent disciple Rudolf Brdička, who was habilitated at the University of Prague in 1930's, devoted his work to the application of polarography in medicine. He invented a sensible catalytic reaction of hydrogen evolution at polarography of proteins: in the solutions containing the cobalt ions, the proteins render a catalytic bi-wave. This polarographic Brdička's reaction of blood serum had been applied in many countries as a diagnostic one in cases of cancer. In 1930's, we may speak about the Heyrovský's Prague School of Polarography. Among Heyrovský's disciples, we may find latter founders of foreign polarographic schools, for instance Prof. A.P. Vinogradov in Russia, Prof. Shikata in Japan, Prof. Semerano in Italy, and many others. In Poland, it was W. Kemula.

While Kemula was deprived of access to the scientific research between 1941 and 1945, Heyrovský's laboratory stayed at his disposal due to friendly efforts of Prof. J. Boehm, a German anti-Nazi, throughout the WW II years. In fact, the Czech universities were closed by the Nazis in 1939 November.

After WW II Heyrovský had to face the accusation of collaboration. However he was completely rehabilitated soon and his approaches had been fully justified.

Thus, Heyrovský could conduct his experiments as well as launch a new research — oscillographic polarography. During the war, the bilateral correspondence between Heyrovský and Kemula was interrupted, but it was restored immediately after the termination of the war. The Prague Academy of Sciences Archives preserve Kemula's letters to Heyrovský dated between 1945 and 1965 as well as transcripts (carbons) of Heyrovský's letters to Kemula dated between 1950 and 1965. The remaining correspondence should be sought for in the Polish archives.

The post-war correspondence portrays the complicated conditions as in Poland, entirely destroyed by the war, the university tuition had to resumed, not speaking about the scientific research. After the war, Kemula was assigned for a brief term to the Jagellon University in Cracow where he lectured in physical chemistry and, since the 1945 autumn, Kemula took over the Chair of inorganic chemistry in Warsaw, where he gave lectures in physical chemistry, apart from others. The Warsaw University had been badly damaged, including its Institute of Chemistry, built and equipped in 1939. Kemula writes that he has no plants, virtually nothing at his disposal. In his words,

I give lectures in inorganic and physical chemistry without gas and water, no glass available, not even a glass tube. All experts in glass plants perished in camps in Germany. There was a big feast at the Institute last week: old analytical balance was bought....

He enquires of Heyrovský, how much would be a new polarographic plant, the entire apparatus, etc. and requests the delivery of the *Collection Journal*. Kemula travels round Denmark and Sweden in 1946 spring, making all efforts to obtain some plants for laboratories. He writes to Heyrovský that he still does not possess even an electrolytic vessel for his students. The polarographs that he had seen abroad are inaccessible due to price reasons for the Warsaw University. He even could not buy Heyrovský's textbook "Polarography", this being so expensive in Denmark. He expresses his thanks to Heyrovský for the offer of books and for *Collection Journal* that might be pouched through the Embassy. Both of that arrived to Warsaw safely in 1946 December. After WW II Heyrovský handed over the lecturing in physical chemistry to his disciples, R. Brdička and M. Kalousek, while he himself gave lectures merely in his polarography — both at the university and during his journeys abroad (England, Sweden, Denmark, China, Egypt, etc.)

According to the correspondence, the electrochemistry research has been re-launched in Warsaw, despite all the difficulties. Kemula offered one of his papers to Heyrovský in order to be published in

Collection journal. As Dean of the Faculty of Mathematics and Natural Sciences in Warsaw, suggested that Heyrovský be conferred Honorary Doctor there, at the beginning of 1947. However, this degree was conferred upon him in 1950 May only (the delay was caused by the Polish Ministry of Education who leared of the alleged Heyrovský's collaboration with the Germans). Heyrovský could obtain his diploma only in 1956 February as he was participating at an international polarographic conference held in Warsaw. He could not assume his diploma in 1950 spring, for he had not been granted a passport for his journey to Poland. Heyrovský was rather irritated at that time, as he had intended to give lectures on polarography at the occasion of his visit.

Meanwhile Kemula did his best to introduce the method of polarography into praxis. This may be testified, besides others, by his recommendation to Polish scientific plants' importer to purchase the polarographs in Czechoslovakia, as these are inexpensive and the very best ones. It was a kind of comedown for the Poles that the orders had been executed slowly and the polarographs supplied turned to be unreliable. Apparently, this could not please Heyrovský but he was not competent to handle the complaints. Heyrovský was pleased to hear (1949 October) that the Polish students who had participated in polarographic practicum at his laboratory came back home very content. In the mid-1949, Kemula already succeeded to launch the operation of his laboratory equipped with polarographs, for he informs Heyrovský that an exact polarographic method to determine fluorine in drinking water had been already elaborated.

Heyrovský's long-time dream to possess a polarographic institute of his own was materialized on April 1, 1950. On this very day, the Central Institute of Polarography was established; at the beginning, there were merely four employees plus Heyrovský as Director. Heyrovský mentions that in his letter to Kemula dated April 5, 1950. He indicates that he would leave the University, the Institute of Physical-Chemistry there to be taken over by his prominent disciple Rudolf Brdička, while he would devote in further all his efforts exclusively to the new Institute.

Kemula informs Heyrovský (1950 July) that his laboratory elaborated the accurate analytic method of polarometric determination of oxygen in water. As he requires the separates of papers on oscillographic polarography, it seems he intends to introduce this method in Warsaw. In September 1950, Heyrovský writes to Kemula on a planned international congress on polarography to be held in Prague in 1951 February. He indicates downright that all depends from Moscow, an implication of political background. Kemula replied immediately that he would like to attend the advised congress together with his disciples to show them the place where polarography had been born. By the same mail, he offered three papers to be presented during the congress. Heyrovský accepted them and had them published in congress proceedings. The above-mentioned congress took place really in 1951 February. Kemula arrived, accompanied by his wife, by his old companion from 1930's M. Michalski and by two young polarographers. So the two scientists met personally after a pause of 20 years in 1951 February. The reunion must have been an extremely cordial one, as both of the professors address each other in their further correspondence in familiar form ("thou"), mentioning often matters of their families, too. In one of his letters, dated 1952, Heyrovský recalls Kemula's narrations on his violent struggle for existence and permanent endangering during the war years. He writes:

We consider thee as leading physical chemistry scholar of Poland — with Swietoslowski — and as such, we pay honours to thee on behalf of my Czech colleagues as well as myself with the expression of admiration and respect. As thy old friend, I shake thy hand most cordially...

Obviously, this is a brilliant evaluation of Kemula by his scholar Heyrovský. The exchange of short-time assigned scientists has been also launched between the Czech and Polish institutes of polarography. For completeness' sake we have to mention that the polarographic research — apart from the new Central Institute for Polarography — was conducted at the University, too, under the tutelage of Prof. Brdička, while the Polish short-time assigned scientists were guests of both of the institutes. The Central Institute for Polarography has been incorporated — as Institute of Polarography — into the newly established Czechoslovak Academy of Sciences.

Meanwhile (Warsaw, 1952), Kemula elaborated a new method denominated as chromatopolarography—a combination of chromatography and polarography. The first papers concerning this new method were published in a Polish professional journal in the same year. Kemula continues to send over to Prague

young promising researchers to gain experience. There are, however, Czech physical chemists who part for Poland on short-time stays. These are mostly research fellows of the Institute of Polarography (for instance P. Zuman in 1954, J. Koryta and J. Kůta in 1955, I. Smoler in 1957, plus others). There is an intensive research conducted at the Kemula's laboratories as testified by numerous publications both in Polish and in world languages, their authors being Kemula and his young fellows, in fact Kemula's School of polarography. We have to note that a part of Kemula's disciples worked at the Institute of Chemistry at the University of Warsaw, while others were fellows of the Institute of Physical Chemistry in the Polish Academy of Sciences. Kemula became Senior Research Fellow at both of these Institutes. Kemula also talked with Heyrovský on translation of Heyrovský's "Introduction to Practical Polarography" into Polish. He suggested the monograph be completed with a chapter on chromatopolarography (Heyrovský consented with 3–4 pages) as well as with a chapter on oscillographic polarography (also 3–4 pages, according to Heyrovský). Even translators were selected among Kemula's collaborators. A conference on polarography was held in Warsaw in 1956 February, attended — apart from other Czech polarographers — by Heyrovský himself, who delivered one of principal papers devoted to oscillographic polarography with alternating current. It was Kemula as Organizational Committee Chairman who requested the paper/lecture to be delivered by Heyrovský.

Professional problems of polarography are often discussed in Heyrovský / Kemula correspondence. Heyrovský does not hesitate to criticise his friend Kemula's works. In December 1956, he writes, for instance:

I was rather worried of how shallowly have you entered into the measurements of oscillograms, as your work does not contain numerous errors and imperfections.... According to the errors that I briefly indicate I consider your way of assessing the potentials as an old-fashioned one and inaccurate and in this sense I shall submit my reaction on your publication. With cordial regards to thee I remain thy old and always frank scholar.

The matter of concern was Kemula and Kublik's work conducted four years earlier ago when the measurements was not that sophisticated, while Kemula's institute did not have financial coverage for a more up-to-date plant. Kemula's explanatory letter mentions towards the end:

Unfortunately I have to admit that did not take due attention that the text of the publication were duly edited for print. By fortune it came that the proof sheets came into thy hands and, following the corrections, the article should be edited in such a form that any further discussions in journals would be redundant.

The scientific dispute came thus to its end towards the end of December. In the autumn 1956 the Nobel Prize for Chemistry Committee addressed Kemula to suggest a suitable candidate for 1957 award ... Kemula does not hesitate a single moment, suggesting to Stockholm in 1957 January that the Nobel Prize be awarded to the inventor of polarography, Prof. Heyrovský, informing also the candidate accordingly. Finally, Nobel Prize for Chemistry was awarded to Heyrovský for his invention and elaboration of analytical polarographic method in 1959. Upon this occasion many of his Polish friends-polarographers were congratulating him, with Kemula as one of the first to come. He namely, as he mentions in his letter to Heyrovský, watched the TV transmission of Nobel Prize Award Ceremony held in Stockholm on December 10, 1959. Kemula's laboratory also produced an important idea of hanging drop mercury electrode. Independently from Kemula, the Czech polarographers V. Čermák and J. Vogel also pampered the very same idea. The hanging drop electrode designated as Kemula's electrode was to find a widespread usage, being produced by different companies. Kemula paid his visit to Heyrovský in Prague during the summer months of 1960. It seems to be their last personal reunion — apparently a most cordial one.

It was Kemula, too, who proposed Heyrovský to become the Foreign Associate Member of the Polish Academy of Sciences. Heyrovský feels obliged to thank Kemula, writing:

My dear friend, thy letter stating that I was elected Foreign Associate Member of the PAS had pleased me enormously. I was conferred the highest scientific dignities that might be achieved in Poland. I know for sure it had been due to thy efforts, by thy promotion of polarography and upon thy direct proposals. I accept this appointment, being fully aware

of the honour granted to me, to my Institute and to my country. May I ask you to accept the expression of my most cordial gratitude ...

Heyrovský took over the Foreign Associate PAS Member diploma in 1962 autumn.

Apparently, the two protagonists kept on greeting each other to their birthdays, to X-mas etc. They informed each other on their journeys abroad as well as on the latest works in their branch of research, they exchanged books of which they were authors and, in particular, followed closely the development in electrochemistry, by their disciples in particular. Heyrovský resigned to the post of Director of the Institute of Polarography due to health reasons. Provided his state of health afforded him, he diligently visited his Institute — his laboratory and his office — to handle the voluminous correspondence, to participate in polarographic colloquies or to complete the bibliography of works in polarography, as he had been already doing so for tens of years. Following Heyrovský's proposal, Kemula was elected Honorary Member of the Czech Society for Chemistry. Shortly before Heyrovský's death, his wife writes to Kemula, mentioning her husband's illness and his being hospitalised at the State Sanatorium with internal complications. Heyrovský deceases in Prague on Easter Monday, March 27, 1967. During his life still, quite exceptionally, the Institute of Polarography took the name of The Jaroslav Heyrovský's Institute of Polarography, in order to appraise the merits of the inventor of a new physicochemical method.

The J. Heyrovský's heritage contains further correspondence between him and other Polish polarographers, namely J. Chodkowski, M. Michalski, J. Witwicki, B. Behr and others. On distance, Heyrovský sometimes suggests how to solve special issues, in oscillographic polarography in particular, meets the requests for assistance with spare parts of Czech polarographs, etc.

For the sake of completeness, we have to note that W. Kemula was author or co-author of more than 400 scientific works. The first of them had been thematically focused on polarography, the latter ones include other electrochemical disciplines as well as those of general physical chemistry. Kemula, likewise Heyrovský, kept on publishing nearly until his death. Kemula's activities were nearly suicidal during the 1940's – 1970's. Kemula was Full Professor in inorganic and physical chemistry, for many years Dean and Vice-Dean at the Faculty of Mathematics and Natural Sciences of the University of Warsaw, Senior Research Fellow (Head of Department) at the Institute of Physical Chemistry in PAS, editor of *Roczniki Chemii* (Yearbooks of Chemistry), later of the Polish Journal of Chemistry, etc. He died in Warsaw on October 17, 1985. Beside chemistry, Kemula also loved music. He was fluent in eight languages (including Czech); with Heyrovský, he corresponded in Czech, his written communication being amazing. The Commemorative Medal of the Polish Society for Chemistry bears his name, testifying thus his merits for the Polish chemistry.

To conclude, let us name the most prominent Heyrovský's and Kemula's disciples, i.e. the Czech and the Polish polarographic schools. As an annex, let us also mention the Brdička's school. We mention merely the names of Czech and Polish polarographers, future professors and associate professors that have generated further polarographers of the future.

Jaroslav Heyrovský School:

R. Brdička (1906–1970), D. Ilkovič (1907–1980), J. V. A. Novák (1913– ?), M. Kalousek (1915– ?), J. Forejt (1915–1991), J. Kůta (1924–1981), M. Matyáš (1923), P. Zuman (1926), J. Volke (1926), J. Dvořák (1927–?), A. A. Vlček (1927–?) , L. Treidl (1930), R. Kalvoda (1926), A. Tockstein (1926)

Wiktor Kemula School:

M. Michalski, H. Buchowski, Z. R. Grabowski (1927), J. Chodkowski, S. Siekerski (1926), Z. Galus (1934), A. Hulanicki (1929) S. Rubel, Z. Kublik (1922), M. K. Kalinowski, B. Behr, J. Strojek

Rudolf Brdička School:

K. Wiesner (1919–1986), V. Čermák (1920–1980), V. Hanuš (1923), J. Koutecký (1922–2005), J. Koryta (1922–1994), V. Kalous (1926)

Timeline of life and activities of J. Heyrovský and W. Kemula

- 1890 — Heyrovský born
- 1902 — Kemula born
- 1918 — Heyrovský graduates (Ph.D.), impulse to study electro-capillarity of mercury
- 1920 — Heyrovský habilitated at the University of Prague
- 1922 — Heyrovský invents electrolysis with dropping mercury electrode, becomes Extraordinary Professor in physical chemistry
- 1925 — Heyrovský and Shikata construct their first polarograph
- 1926 — Heyrovský appointed Full Professor in physical chemistry at the Prague Charles University
- 1927 — Kemula awarded PhD, becomes Assistant to Prof. Tolloczki in Lwow
- 1929-1930 — Kemula's assignment in Prague, gets acquainted with polarography, his first polarography papers
- 1932 — Kemula habilitated in Lwow
- 1936 — Kemula becomes Associate Professor of physical chemistry in Lwow
- 1939 — Kemula appointed Full Professor at the University of Warsaw
- 1942 — Heyrovský's first works in oscillographic polarography
- 1949 — Heyrovský appointed Honorary Member of the Polish Society for Chemistry
- 1950 — Institute for Polarography established in Prague, Heyrovský becomes its Director, also appointed as Honorary Doctor at the University of Warsaw
- 1951 — 1st International Congress on Polarography held in Prague with Kemula's participation
- 1952 — Heyrovský appointed Member of the Czechoslovak Academy of Sciences, Institute for Polarography incorporated in CAS
- 1953 — Polish researchers in electrochemistry at assignments in Polarographic Institute, Kemula's chromatopolarography
- 1956 — Heyrovský takes over his Honorary Doctor's diploma in Warsaw, polarographic conference held in Warsaw with Heyrovský's participation
- 1957 — Kemula suggested Heyrovský to be Nobel Prize candidate
- 1958 — Kemula's hanging drop mercury electrode
- 1959 — Heyrovský becomes Nobel Prize Laureate for Chemistry
- 1961 — Kemula becomes Full Member of the Polish Academy of Sciences
- 1962 — Heyrovský becomes Honorary Member of PAS
- 1966 — Kemula becomes Honorary Member of the Czechoslovak Society for Chemistry
- 1967 — Heyrovský dies
- 1985 — Kemula dies