



AVIEZER STEVAN KERTES

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## THE SCIENTIFIC CAREER OF AVIEZER STEVAN KERTES: A PERSONAL APPRECIATION

Aviezer Stevan Kertes, known as Steve to his friends outside Israel, was a leading figure in the community of researchers on solvent extraction chemistry and the initiator and leader of the Solubility Data Project of IUPAC. He left us suddenly on July 8, 1988 at the age of sixty-six, in the midst of what were always hectic but highly efficient activities in his many fields of endeavor.

Steve Kertes was born in Szeged, Hungary, near the Yugoslav border, on May 11, 1922. This circumstance led to his fluency in both Hungarian and Serbian, to which languages he added in due course French, English and Hebrew. His scientific and technological education began at the University of Belgrade in Yugoslavia, where he obtained his M.S. degree in chemical technology in 1949. In this year he emigrated to Israel, where in Jerusalem he started and conducted his scientific career, except for a postdoctoral fellowship, periods of sabbatical leave and summer vacations spent at various institutes all over the world.

As a result of his training in chemical technology, Steve started his career at the laboratories of the Dead Sea Works, Ltd. which at that time were located in temporary accommodations in Jerusalem. It was also at this time that I first made his acquaintance, which slowly grew into a lasting friendship. In 1950 Steve quit that job and enrolled as a doctoral student at the Hebrew University of Jerusalem, under the supervision of the late Prof. Mordecai Max Bobtelsky. His Ph.D. thesis dealt with metal superphosphates and their complexes, and made extensive use of a solubility method. Later on, although Steve did not value his thesis greatly, he returned to the general problem of solubility with contributions of large scale and enormous impact. He obtained his doctoral degree in 1953, and continued for a time as an assistant in Prof. Bobtelsky's department.

The scientific career of Steve Kertes really took off once he accepted a postdoctoral fellowship with Prof. Michael Lederer at the Institut du Radium in Paris, where he stayed from 1955 to 1957. He learned there the use of radioactive tracers and came into contact with radiochemistry and nuclear technology, areas with which he maintained contact in later years. Steve's research in Paris concerned the use of paper chromatography for the study of metal complexes in aqueous organic - mineral acid solutions. When he was appointed a lecturer at the Hebrew University in Jerusalem in 1957 he continued this kind of research for some time with his first graduate student, Anna Beck.

Soon Steve decided that the key to the understanding of metal complexation in aqueous organic - mineral acid solutions was a deep knowledge of the physical chemistry of these solvent systems. He therefore started a series of studies with his wife, Vera, and graduate students Anna Beck, Jacob Elhanan-Habousha and Mordecai Halpern that dealt with these systems, in particular those in which the organic solvent was tri-*n*-butyl phosphate. This solvent, of prime importance in the reprocessing of spent nuclear fuel, was at that time under intensive study all over the world, but Steve found important aspects that became his domain, in particular the formation of three liquid phases in systems involving it. To be sure, this again is a solubility phenomenon, a subject that was not left alone by Steve throughout his career. Besides three-phase formation, Steve's team also studied the properties of extraction systems with tri-*n*-butyl phosphate and its degradation product, di-*n*-butyl phosphate, as applied to hydrochloric, hydrobromic, and perchloric acids, uranyl chloride and perrhenate salts. With these studies Steve joined the community of researchers dealing with solvent extraction, and he eventually became a leader in this community.

Extraction by means of these phosphate esters occupied Steve's attention during the late 1950's, but in the early 1960's he turned towards a new class of extractants: long-chain substituted ammonium salts. By 1962 a few publications with his students and coworkers Anna Beck, Jacob Elhanan-Habousha and Isaac Platzner concerned these extractants. At that time, I was doing radiochemical research at the Soreq Nuclear Research Center, and contact between Steve and myself was renewed, with far-reaching consequences.

In 1962 Steve went for his first sabbatical leave, which he spent at M.I.T. in Cambridge, Massachusetts with John W. Irvine, staying there till 1964. That was the time when Steve began to forge lasting friendships with a great number of colleagues whom he met at M.I.T. or elsewhere in the United States. These friendships later helped him to find collaborators for the Solubility Data Project and to find places to spend summer vacations where he could engage in scientific activities with others besides his students and colleagues in Jerusalem. His chemical research at M.I.T. concerned long-chain substituted ammonium salts in nonpolar organic diluents, a subject that continued to be in the center of his interest all through the 1960's.

The collaboration between Steve Kertes and myself crystallized in 1962 with a contract with John Wiley & Sons Ltd., then in London, to write a monograph on *Ion Exchange and Solvent Extraction of Metal Complexes*. This task took us more than four years, and it was not until February, 1967 that we could take out our wives for a dinner to celebrate having sent the completed manuscript to the publisher. These years were not easy for us. I was appointed in 1965 as a professor at the Hebrew University and became the head of the department at which Steve taught. There were periods of despair and tensions between us, but our satisfaction with the finished work - a book of 1050 pages published in 1969 - and with the impact it had on the scientific community overcame them all. Our names became household words in all the laboratories where ion exchange or solvent extraction were used to separate metal ions, and we received numerous invitations to lecture at conferences, symposia, universities and research institutes. Steve's contributions to our book were essential to its success and to the impact it had, so that my own career was much enhanced by this partnership with him. When Steve Kertes returned in 1964 from M.I.T. to his position in Jerusalem he dealt throughout the remaining 1960's and the early 1970's, together with his graduate students George Y. Markovits, Oscar Levy and Hilda Gutmann, with the behavior of long-chain substituted ammonium salts in organic solvents and in particular with their aggregation. A wide variety of physico-chemical methods served for this purpose. X-rays were used for structure determination of the solid salts (in collaboration with Prof. I. Mayer) and studies of their infrared spectra established their hydrogen-bonding properties. The viscosity, conductivity, dielectric constant and in particular the vapor pressure, measured by a thermal osmometric method, helped to elucidate the aggregation of these substances in solution. A long series of publications reported on these studies.

Steve's diversity of interests were shown during another sabbatical leave in 1968/69 with Dr. Leonard Katzin at the Argonne National Laboratory in Argonne, Illinois, where he also collaborated with Dr. John Ferraro in studies of some chelate complexes. With another graduate student, Freddy Kassierer, he studied at that time the synergistic extraction with chelating extractants, and he also collaborated on this subject with Dr. Mendel Zangen of the Soreq Nuclear Research Center in Israel. The late 1960's and early 1970's constituted the peak of Steve's activities in the field of solvent extraction chemistry. He co-organized with me ISEC '68 (the 1968 International Solvent Extraction Conference) in Jerusalem and we co-edited its proceedings. At ISEC '74 in Lyon, France, he was elected to the international steering committee for these series of conferences, a position he held till 1986. His many contributions to this field were further recognized with a citation of merit at the ISEC '83 in Denver, Colorado, and finally, but alas posthumously, with the Carl Hanson medal at the recent ISEC '88 in Moscow.

The early 1970's were also an extremely fruitful period of Steve's research with his graduate students. Hilda Gutmann completed her work on the aggregation of long-chain substituted amines and their salts in non-polar solvents, and she and Steve arrived at quite unconventional conclusions. These were that in these systems aggregation proceeded to yield a series of rather small oligomers, and that neither inverted micelles were formed, nor was the concept of critical micelle concentration valid for them. Fernanda Grauer and Liliane Tsimering measured, under Steve's supervision, the heats of mixing and dissolution of extractants in various diluents by means of precise calorimetry, and contributed thereby a new dimension to the thermodynamics of solvent extraction. Steve's summer-long stay in 1970 with Prof. Robert Guillaumont in his radiochemical laboratory of the University of Paris in Orsay brought him into contact with the field of molten salt chemistry. He then collaborated with Dr. Zangen at Soreq in the supervision of another graduate student, Judith David-Auslaender, studying extraction from molten salts with organic solvents. In another summer, 1977, at the City University of New York with Prof. Harmon Finston, Steve participated in work on the homogeneous liquid-liquid extraction of metal thenoyltrifluoroacetates. Again, the diversity of Steve's interests and his ability to collaborate with others are hereby exemplified.

All through the 1970's publications appeared in the field of solvent extraction chemistry by Steve with his students and former students Markovits, Levy, Gutmann, Grauer and Tsimering. However, his main interest was diverted in the early 1970's in other directions. Two factors contributed mainly to this development. One arose from the work on the long-chain amines and the question of their micellization, the other from his election in 1967 to the Commission on Equilibrium Data of IUPAC (the International Union of Pure and Applied Chemistry), to deal initially with liquid-liquid distribution constants. The work on the aggregation and eventual micellization of the salts of long-chain substituted amines led naturally to Steve's interest in colloid chemistry, surface active substances, and microemulsions. The summer of 1973 that he spent in the Institute for Surface Chemistry in Stockholm and the subsequent sabbatical leave as a visiting professor during 1973/74 in McGill University in Montreal, Canada consolidated Steve's interaction with these fields that were up to then new to him. As a consequence he was able to act as a consultant in an industrial firm, Armac in Chicago, where he spent another sabbatical leave in 1979/80. The questions that he dealt with concerned soaps, that is, salts of long-chain carboxylic acids, in non-polar or in aqueous-organic solvents. Other problems that he investigated concerned the formation of inverted micelles and microemulsions in systems involving polar solvents (short-chain alcohols), water, salts and nonpolar organic substances (solvents) that could be solubilized in such systems. Experimental studies on such systems were conducted in his laboratory by Lilian Tsimering (in collaboration with Prof. N. Garti of the Hebrew University) and a new graduate student, Wen-Chao Lai, in the late 1970's and early 1980's. Steve's stay in the summer of 1982 at Drexel University in Philadelphia was in this connection. His reputation in this field caused him to be nominated to the editorial boards of two scientific journals in the fields of colloid and surface chemistry, and to his chairing the 4th International Conference on Surface and Colloid Science in Jerusalem in 1981.

After election to IUPAC's Commission on Equilibrium Data in 1967, Steve started on projects of compilation and critical evaluation of equilibrium constants pertinent to solvent extraction together with Dr. Eytan Yanir and myself. He soon realized the importance of accurate data and their efficient transfer from the primary scientific literature to secondary and tertiary sources. He therefore found his way to CODATA (Committee on Data for Science and Technology), and became in 1972 a member and, since 1977, the chairman of the Israel National Committee for CODATA. This activity culminated in the organization by Steve of the 9th International CODATA Conference in Jerusalem in 1984, and his acting as its chairman. He continued with work for CODATA as a member of its task groups on the accessibility and dissemination of data and of education in the use of data. Within the IUPAC Commission on Equilibrium Data (Commission V.6) Steve sought for an activity that would fit his abilities and interests but would also have far-reaching consequences. He came to the conclusion that existing data on *solubilities*, which are fundamental not only to chemistry and chemical technology but also to many other branches of science and engineering, were in poor shape, being neither comprehensive nor particularly reliable. He therefore proposed to the Commission on Equilibrium Data of IUPAC that it should engage in a project of compilation and critical evaluation of solubility data. This proposal led to the creation within the commission in 1971 of a task group (consisting first of D.N. Hume, A.S. Kertes and F.J.C. Rossotti; later G.H. Nancollas replaced F.J.C. Rossotti). This task group examined the feasibility of such a project, and recommended that the Commission should undertake it under a subcommittee of Commission V.6. This was, indeed, authorized by IUPAC in 1973, and Subcommittee V.6.1, under the chairmanship of Steve Kertes, was created.

The task of Subcommittee V.6.1 was to formulate the scope of the project, establish the mechanism of the work of compilation and evaluation, define the format of the output, and find the means for its publication. Steve was the ideal person to handle both the organizational and scientific details of this task. His superb social qualifications permitted him to enlist hundreds of volunteers to work on the *Solubility Data Project*. He was very particular regarding who would be qualified to help. He wanted professional chemists who had experience in chemical research involving solubilities and had a stake in the accuracy of such data. Such people would naturally have interests in restricted areas of the whole field of solubility, and this meant that the project would have to be subdivided into many small sub-tasks. The overall picture would then be in the hands of topic editors and the editor-in-chief. Extended guidelines were prepared for compilers and evaluators, and sample compilations and evaluations were solicited from highly qualified colleagues. The scientific organization in topics and sub-topics was agreed on in many meetings, both at IUPAC General Assemblies and otherwise. In this connection, Steve stayed for a summer with Prof. Larry Clever at Emory University in Atlanta, Georgia. The onerous task of finding a publisher for the project fell to Steve, who travelled far and wide and had discussions with numerous potential publishers till one was found that finally took upon itself the financial risks (and eventual profits), Pergamon Press of Oxford, UK.

Thus, as in 1979 the first volumes of the *Solubility Data Project* were published, the time was ripe to remove the project from under the auspices of Commission V.6, and IUPAC authorized the creation of the new full-fledged Commission on Solubility, V.8, under the chairmanship of Steve Kertes. According to IUPAC's rules Steve had to relinquish this chairmanship after eight years, in 1987, and this retirement was celebrated at a memorable dinner at the Boston General Assembly of IUPAC. Steve retained the position of Editor-in-Chief, and within IUPAC's Analytical Chemistry Division Committee, to which he was elected in 1987, he continued to make Commission V.8 aware of his concerns and to provide it with advice. By now 40 volumes of the *Solubility Data Project* have been published, and more are in various stages of preparation, the project being viable and of lasting value and service to the chemical and other scientific communities.

Steve Kertes was also instrumental in calling into being a new series of international conferences, the *International Symposia on Solubility Phenomena*, the third of which took place in Guildford, UK after Steve's death. But while most of Steve's seemingly unlimited energy was channeled into organizational and editorial activities, he did not relinquish original scientific research in the field towards which most of his career was directed: *solvent extraction chemistry*. The opportunity for this arose from Steve's last sabbatical leave, which he spent with Prof. C. Judson King at the University of California in Berkeley in 1984/85, plus an additional summer in 1987. He supplemented Prof. King, who was busy with administrative duties, as the supervisor and counsellor of a number of graduate students. The team studied the solvent extraction of organic solutes from aqueous solutions, and two review articles by King and Kertes appeared in Steve's lifetime, one on the extraction of carboxylic acids and the other on the extraction of alcohols. The original research results will have to be published without Steve's very critical and painstaking evaluation. A further aspect of solvent extraction to which Steve returned in recent years was the behavior of tri-*n*-butyl phosphate as an extractant of acids, a subject that he studied experimentally some thirty years previously, and which was the subject of a volume that Steve co-edited a few years ago.

The very active career in science pursued by Steve Kertes, consisting of a harmonious mixture of teaching, original research in solvent extraction and surface chemistry, and organizational and editing activities, particularly in the field of solubilities, did not seem to affect Steve's health or diminish his energies. Despite quitting smoking a few years ago, he did suffer from shortness of breath, but otherwise did not appear to be approaching the age of retirement from his professorship at the Hebrew University or from his numerous other activities. He was full of plans for the near and far future, ranging from what he was going to do at the Catholic University of Leuven during his visit with Prof. Pierre Huyskens this past summer and his invited contributions to the ISEC '88 in Moscow and the 26th ICCS (International Conference on Coordination Chemistry) in Porto, Portugal, to his research with graduate students in Berkeley plus other old and new projects. These plans will never be realized now, and the scientific community of which he was such an active member will have to learn to do without him.

But it is not only projects that Steve's early demise leaves unfinished, nor not only colleagues that it leaves without a dedicated collaborator. Steve left Vera, his wife and lifelong companion and helper on voyages around the world, his daughter Tamar and son Amnon and their spouses and his two grandchildren in want of a devoted husband, father and grandfather. He left his very numerous friends on all continents the memory of a man of a charming and warm personality, who would always stand by them with advice and help if need be. Steve Kertes has left his mark not only on the fields of science in which he was active, but also on the minds and hearts of all of us, his friends.

Yizhak Marcus

Jerusalem, November, 1988