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Obituary

Professor Ernst Bayer (1927–2002)

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It was with great sadness that his associates, former coworkers and friends around the world learned the news of the passing of Professor Ernst Bayer on January 31, 2002, in Tübingen. They feared for him since March 2000 when they learned at the ACS Spring meeting in San Diego (CA, USA) that Professor Bayer was suffering from lung cancer. Yet, everyone present at that meeting keeps the memory of his brilliant Chromatography Award address during which he demonstrated his mastery of analytical and physical chemistry and his fortitude.

Born on March 24, 1927, in Ludwigshafen, Professor Bayer was educated there. He became a Diplom-Chemiker in 1952, at the University of Heidelberg, with a Diplomarbeit in physical chemistry and received a Ph.D. in 1954 at the University of

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Freiburg, for research done under Professor Richard Kuhn at the Max-Planck Institute of Medical Research in Heidelberg [1]. The Ph.D. research of Professor Bayer was on hemovanadine, the vanadium compound that gives its color to the blood of tunicates. So began a career dedicated to the elucidation of the structure of natural compounds. Exceptional among organic chemists, Professor Bayer had a solid education in physical chemistry that explains his constant interest in using or developing the most advanced methods of analytical chemistry to solve fundamental problems in the chemistry of natural products. In so doing, he accumulated many remarkable achievements in our field.

After a brief stay as Head of the Chemistry and Physiology Department of a governmental research institute in 1955–57 (where he did his impressive work on wine analysis, see later), Professor Bayer followed the conventional German curriculum and became Professor of Organic Chemistry at the University of Tübingen in 1962. He stayed there, directing the world famous Institut für Organische Chemie, until his retirement in 1995, when he became Head of the Research Center of Nucleic Acid and Peptide Chemistry of the University of Tübingen. At various times, he held important positions at the University of Tübingen and in the scientific establishment of Germany, particularly in the Gesellschaft Deutscher Chemiker and as Head of the (German) Government Committee on Environmentally Relevant Chemicals (1982–1998).

In the late 1950s, Professor Bayer pioneered the use of gas chromatography for the analysis of the volatile fractions of wines, the composition of which determines the unique fragrance and flavor of each vintage of this beverage. Major wine makers still use the analytical methods that he developed to follow fermentation and to decide when to intervene to stop those fermentations that lead to poor wines. Professor Bayer analyzed also the aromas of a variety of natural products, e.g., William Christ pear, mushrooms, cheddar cheese, rum, and hops. This field, which has undergone considerable development since the 1970s, was pioneered by Professor Bayer who published in 1959 the first analysis of a pheromone, that of the silk moth, using a live male butterfly as the selective detector.

In 1970, Professor Bayer reported the first separation of amino acid enantiomers on peptide stationary phases and published in 1977 the simultaneous separation of the enantiomers of all the proteinic amino acids. The high thermal stability of the polysiloxane (''Chiralsil-Val'') that he developed led to its successful use for the chiral analysis of amino acids for the last twenty years, e.g., for the investigation of the racemization of amino acids under different sets of experimental conditions, for the determination of the geological age of fossils, for the search for possible traces of life in moon rock samples, and for trace analysis by enantiomeric labeling.

In 1958–1965, Professor Bayer was one of the pioneers of preparative GC. Using 10 cm I.D. columns, he investigated the phenomena causing the loss of efficiency at large diameters and designed an equipment, later commercialized by his coworker, Dr. K.P. Hupe. Professor Bayer's coworkers used this equipment for the isolation of fractions of aromas and other complex organic mixtures of natural origin, prior to more efficient GC separations or, later, LC separations.

Professor Bayer published the analysis of complex peptide mixtures in 1973 and detected the inherent failure sequences in solid-phase peptide synthesis (SPPS). This resulted in the optimization and improvement of SPPS and made HPLC the standard method for SPPS control. He published analyses of complex mixtures of peptides by HPLC in 1973. In 1976, he reported the first separation of the dansyl derivatives of the amino acids with fluorescent detection, reaching detection limits in the femtomole range, a performance that continues today. Using separations and purifications by HPLC and hyphenated combinations of LC with MS, NMR, and ESR, Professor Bayer identified hemerythrin, ferrodoxin, amavadin, phosphinothricin, the first natural amino acid containing the element phosphorus (and now used as a natural herbicide, BASTA), morulin, tunichromes, and numerous humic compounds. This impressive list of compounds illustrates the scope of the organic research undertaken in Professor Bayer's group and the great importance he paid to analyses and particularly to HPLC.

In 1974, Professor Bayer invented the method known as ''Template Chromatography'', for the separation of peptides and nucleotides. This method uses specially synthesized oligonucleotides, immobilized on DEAE cellulose, as the stationary

phase and is especially suitable for the study of molecular interactions between peptides and nucleotides.

Professor Bayer published important studies on the structure of the stationary phases obtained by chemically bonding alkyl groups to silica. Using a combination of cross-polarization (CP) and magic angle spinning (MAS) techniques in solid state NMR, he identified the different chemical species involved and correlated them with the synthetic procedure. These 1983 studies contributed greatly to the modern understanding of retention mechanisms in RPLC and to the characterization of RPLC stationary phases.

For thirty years, Professor Bayer was interested in the LC-NMR coupling that is rendered difficult by the relatively poor detection sensitivity of NMR. This method is now standard in the study of pharmaceuticals where it allows the identification of many components of complex mixtures. LC-NMR can now be used with narrow bore LC columns and is commercialized by Bruker and Varian as accessories to NMR instruments.

In 1988, Professor Bayer had members of his group realize movies illustrating the migration and broadening of bands of gadolinium chelates along chromatographic columns. These bands are clearly very thin but warped, the warping originating from the heterogeneity of the packing density and the long-term fluctuations of the mobile phase velocity in the transverse direction. Realizing that the observation of movies is not the best approach for a quantitative study, Professor Bayer had his coworkers carry out measurements of band characteristics on NMR images. Then, he had them develop software based on Fourier transform of the signals acquired with PFG NMR and derive values of local axial and radial dispersion. This work panned out into a major investigation of the heterogeneity of the bed of packed columns, of packing methods, and of the kinetics of mass transfer between the stream of fluid percolating through the bed and the fluid stagnant in the particle pores. This method affords the easy determination of important characteristics of packing materials. It has also the potential of being extended to other important fields of research, e.g., in petroleum engineering, in the investigation of the drift of pollutants in the water table, and in catalysis.

His retirement in 1996 did not stop Professor Bayer's interest for scientific research. He kept busy working on a most active research program. His group developed recently new miniaturized separation methods: capillary HPLC, capillary electrophoresis (CE), capillary electro-chromatography (CEC), and their on-line coupling with MS and NMR. In 1994, he described an instrument that can be used alternately for all three separation methods, even under gradient elution conditions and which can be coupled without interface to electrospray MS. CEC-MS was first published in 1995. Nanoscale NMR detection cells of 80–200 nl were developed and a routine high resolution interface constructed that affords detection limits in the low ng range and the acquisition of 2-D NMR spectra (COSY and TOCSY). Applications of these methods to the identification of peptides, oligonucleotides, drug metabolites and beer bitter compounds demonstrated the progress of this method.

In 1998, Professor Bayer published a new mass spectrometric detection method for on-line coupling with separation methods, Coordination Ion Spray MS (CIS-MS). CIS-MS is based on the on-line, post-column formation of charged coordination complexes that are sprayed and transferred to a MS detector, requiring neither electric field nor physical impact. Nonpolar compounds can be detected which are normally difficult to detect by electrospray MS, e.g., sugars, fully protected peptides, olefins, terpenes, saccharides, lipids by forming positively charged silver or palladium, or negatively charged boron complexes. In MS–MS experiments new fragmentation patterns of coordinated product ions facilitate structure elucidation. As his Award address in San Diego last year, Professor Bayer presented a synthesis of these remarkable achievements that will be long lasting in our memory.

Chromatographers realize that the most brilliant achievements of Professor Bayer are in the organic chemistry of natural products. During his career, he educated, supervised, and advised more than 400 coworkers and the work that they achieved is truly colossal. His achievements are described in nearly 600 original papers in peer-reviewed journals. Under his direction, more than 220 students obtained a Ph.D., and 22 of them went on to become professors. For this work, Professor Bayer received numerous awards and medals, notably the Max-Bergmann Medaille for Peptide Research in 1981, the Philip Morris Research Prize ''Man and the Environment''

in 1985 (for fast, low energy conversion of biomass into oil), and the Richard-Kuhn Medal of the German Chemical Society in 1990. In chromatography, Professor Bayer received, among others, the A.J.P. Martin Award (1978), the Tswett Medal of the USSR Academy of Sciences (1978), the Halàsz Medal (2000), the Golay medal (2000), and the ACS Award in Chromatography (2001).

Professor Bayer was a brilliant lecturer and we all remember his presentations at meetings, all crammed with facts and results, yet illuminated by brilliant insights. He was a man of the Rhine Valley, the Lotharingia which has been the center of Europe for over a millennium and the source of much of its civilization. Professor Bayer was sensitive and cultured, a collector of Aztec artifacts (that he learned to love during his professorship in Houston, TX, 1967–1970), a lover of Italy of which he spoke eloquently and where he used to spend his Summer vacation, and a man with whom any conversation was highly informative. He was a very tolerant and forgiving person. From many I heard harsh judgments made on others, from him none. He was particularly dedicated to his family, cared very much for his wife and, although very discrete about it, showed great concern for the well-being of his children. In his mind, his family extended to his students and former students. He was not a directive mentor, did not give detailed instructions nor followed step by step the development of a project but kept the student focused toward the ultimate goal of the project and supported the efforts to define and solve the problem. He was most proud of their achievements and was always ready to listen to them and give them advice. He was extremely skilled at detecting trends, at selecting fruitful projects and avoiding hopeless ones. At the same time, he was a symbol of scientific integrity and an example for all of us. Professor Bayer was an excellent friend, profoundly respected by the entire community. We offer his family the expression of our heart-felt sympathy.

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References

[1] C.W. Gehrke, R.L. Wixom, E. Bayer (Eds.), Chromatography – A Century of Discovery (1900–2000). Elsevier, Amsterdam, The Netherlands, 2001.