# Ernst Bayer (1927−2002)

To the deep regret of the chemical community, Professor Ernst Bayer of the Department of Organic Chemistry at the University of Tübingen, Germany, passed away on January 31st, 2002, shortly before his 75th birthday. A life devoted to unabated scientific, academic and political endeavour — during which Ernst Bayer gave little regard to the preservation of his health and well-being — was abruptly terminated by a short and incurable illness. The obituary of his close associates read: *Ein Lebenskreis hat sich vollendet und geschlossen, was bleibt sind Erinnerung und Dank.* (*A circle of life has reached its completion, what remains is remembrance and gratitude*).

Ernst Bayer was an exceptional personality and an outstanding scientist. He was born on March 24th, 1927, in Ludwigshafen in the Southern Rhine valley. One is inclined to conjecture that his career as a chemist was not only — *nomen est omen* — spurred from his surname, reminiscent of a large chemical plant in Leverkusen (Germany), but was more likely stimulated by the direct neighbourhood of the IG Farben chemical complex (today BASF) at Ludwigshafen where his father held a position. With environmental matters not yet an issue and with the huge chemical plant nearby, the young Ernst Bayer remembered white laundry on the line turning black during the day and the odour of sulfur compounds penetrating the home at night. Needless to say, this fascinating industrial environment stimulated Ernst to conduct his own chemical experiments at home.

Raised in the Rhine valley of the Palatinate, Bayer's later political aspirations may have been fostered by the fact that he attended the same secondary school in Ludwigshafen as the former Chancellor of the Federal Republic of Germany, Dr. Helmut Kohl. His professional life was set against the background of World War II, the rapid growth of industry and commerce (the German Wirtschaftswunder) and the expansion of institutions of higher education. The loss of his beloved brother at the end of World War II — he himself served in the German navy for a few months close to the end of the war — seemingly shaped his strong ambition to succeed and contributed to his enormous capacity for work over a lifetime dedicated entirely to science and education.

From 1947 to 1952 Ernst Bayer studied chemistry at the Universities of Freiburg and Heidelberg. At the latter institution, where he met his wife Inge — also a chemist — he completed his Master's thesis (Diplomarbeit) in physical chemistry entitled "On the pressure dependence of thermal conductivity depending on the dimerization of chloro-fluoro derivatives of methane", under the guidance of Klaus Schäfer. Endowed with this strong background in

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physicochemistry, between 1952 and 1954 Ernst Bayer conducted his Ph.D. work on the coordination compounds of tri-, tetra- and pentavalent vanadium with organic ligands, in an effort to elucidate the structure of hemovanadine, a vanadium compound occurring in marine tunicates which is responsible for the colour of their blood. This work was performed under the guidance of both Hans-Joachim Bielig and the Nobel Laureate Richard Kuhn at the Max-Planck-Institute for Medical Research in Heidelberg and resulted in a number of publications on hemovanadine, co-authored with Bielig. Thus a career dedicated to the elucidation of the structure of complex natural compounds was initiated.

Richard Kuhn was associated with the re-invention of Michael Tswett′s column chromatographic technique introduced in 1903 (Eugenia M. Senchenkova: Michael Tswett — The Creator of Chromatography, Russian Academy of Sciences, Scientific Council on Adsorption and Chromatography, Moscow, 2003) following the longstanding scepticism of Willstätter towards the merit of this preparative method. The first experience of Ernst Bayer with separation techniques dates back to his time in Heidelberg where he separated amino acids by paper chromatography and when he acquainted himself with electrophoresis.

In the spring of 1955, Ernst Bayer left the stimulating atmosphere of Kuhn's laboratory to become the head of the Department of Chemistry and Physiology of the Federal German Institute of Wine Research at Geilweilerhof in the Palatinate. A major task was to correlate the components of grapes before and after fermentation with the quality of wine. Major wine producers still use methods developed by Bayer to monitor fermentation and to decide when to intervene and to cease fermentations. He reasoned that the organoleptic properties of novel cultivated grapes had to be assayed by efficient analytical methods. His first coworker Klaus Wegmann not only isolated a cyanine oxidase from *Coleus hybridus*, (an enzyme containing copper which oxidizes anthocyanins in the presence of *o*-diphenols), but he also separated mixtures of anthocyanines by paper chromatography and found that their composition was governed by genetic relationships. This work even attracted the interest of customs authorities, in their efforts to single out grapes of foreign origin.

Ernst Bayer was always keen to alert decision-makers on his scientific progress. The anecdote goes that Bayer once talked with local politicians about alcohols and aldehydes at Geilweilerhof. However, one ignorant official wondered about the "old hats" that Bayer said he was dealing with in his laboratory — the pronunciation of the plural of "aldehyde" in German sounds very much like "alte Hüte" ("old hats").

Some of the new red wines cultured at Geilweilerhof, named "Magenreißer" because they were truly *acidic* (pH = 2.2), contributed to science because Bayer observed that the colour was blue rather than red. Thus, the old work of Willstätter on natural anthocyanine dyes was revisited. From the rose-garden in the town of Zweibrücken (and with the help of Stenger, the principal gardener), 200 kg of red rose petals were collected and a few grams of crystalline cyanine were obtained. This diglucoside of cyanidine, responsible for the red colour of roses and the blue colour of cornflowers, was isolated by preparative electrophoresis. The blue colour was recognized as arising from the formation of a chelate of the anhydrobase of cyanine with aluminium or iron. This finding was at odds with the previous assumptions of Willstätter and Karrer who ascribed the colour of blue cornflowers to an alkaline salt of cyanine whereas the red colour of roses was considered to arise from cyanine in an acidic cell medium. This early scientific achievement was re-told by Ernst Bayer in his Abschiedsvorlesung (farewell lecture) entitled: "Into the Blue" (Fahrt ins Blaue) on the occasion of his 70th birthday.

From the outset of his scientific career, Ernst Bayer recognized the importance of the application of versatile analytical tools. It was at Geilweilerhof that he adopted the pioneering work of James and Martin by introducing gas chromatography into Germany to investigate flavours and fragrances of grapes and of other vegetable products. Unfortunately, the first commercial instrument of the American company Podbielnak was expensive and he could not afford it. However, Ernst Bayer managed to obtain a grant from the German Research Council for "building a gas chromatograph", a rather odd research proposal in contemporary terms. This consisted of a 2 m × 10 mm glass tube, packed with chamotte powder, coated with apiezon or silicon oil and using hydrogen as the carrier gas. The gas pressure was controlled by a mercury manometer, and the flow monitored by a rotameter. Despite the archaic set-up, the apparatus worked! With some help from the scientists at Siemens in Karlsruhe (who supplied a thermal conductivity detector) and Hartmann & Braun (who supplied a "Fallbügelschreiber" to record the electric signal), esters and ethers of the flavour of apple cider and of wines could be separated at room temperature. Subsequently, the instrument was completed by an oven, 1.5 m in height, constructed by the company Föll & Leber in Landau (Figure 1).

This separation method soon aroused the interest of analytical chemists at BASF, and Richard Kuhn invited his former associate to give a seminar in Heidelberg in order to present this new technique. Ernst Bayer came to demonstrate his instrument at Heidelberg on February 15th, 1957, a date which became famous as the birthday of German gas chromatography. The gas chromatograph at Geilweilerhof soon became a Mecca for flavour and fragrance companies. Ernst Bayer described the first gas-chromatographic separation of a sex pheromone, namely that of the female silk moth, bombykol (Figure 2), isolated by Butenandt in 1959. He used the excitement of the male moth resulting from the bombykol peak as the principle of an unprecedentedly sensitive biological gas-chromatographic detector.

At Geilweilerhof the foundations toward automated preparative gas chromatography were also laid. Ernst Bayer

  

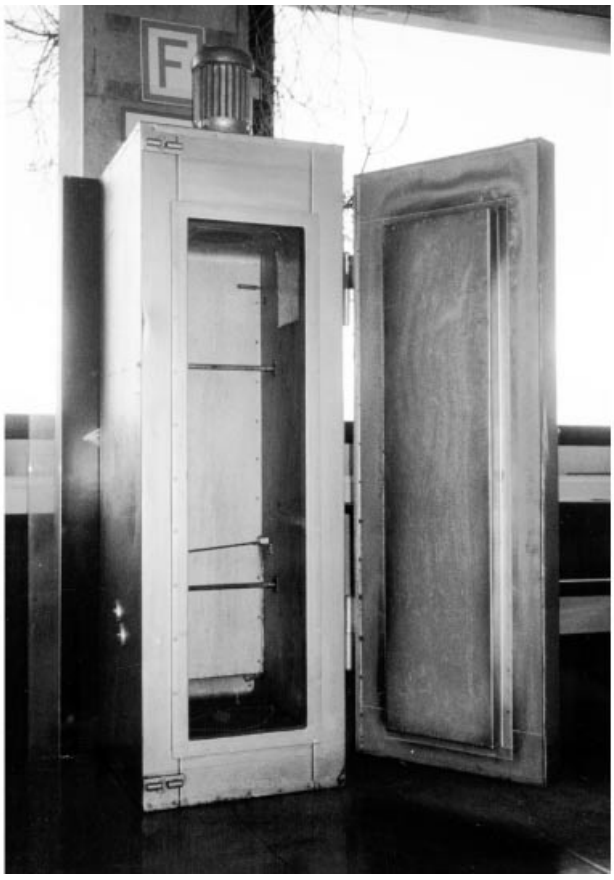

Figure 1. Large oven used by Ernst Bayer for preparative gas chromatography

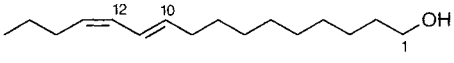


Figure 2. Structure of the insect pheromone bombykol [(*E*,*Z*)-10,12-hexadecadien-1-ol]

developed, together with the engineer Klaus-Peter Hupe, a preparative GC apparatus which was later commercialized by the Hupe & Busch company. Although Ernst Bayer later became deeply involved with hyphenation of chromatography, methods of coupling chromatography with IR, MS and NMR spectroscopy were not yet available at this time, and larger quantities of purified material were required for structure elucidation. With the home-built preparative GC, many natural compounds such as flavour components from Bartlett and Williams Christ pears, cherries, Cheddar cheese and mushrooms were identified. Besides this, the equilibrium between furanose, pyranose, and the aldehyde forms of monosaccharides (fixed by methylation) was investigated. A strong physical chemistry background combined with a sense for practical applications is evident in Bayer's monograph "Gas Chromatography" published in 1958 with Russian and English translations appearing in 1960 and 1961, respectively. In parallel with his activities in the field of chromatography, Ernst Bayer's work on metal chelates from plants and on metalloenzymes led him into the realm of organometallic chemistry. In addition, he embarked on work in the fields of peptides, proteins and (later on) nucleic acids. Ernst Bayer's time at Geilweilerhof was a creative interlude on his way to a fruitful academic career at university.

In 1958, Ernst Bayer accepted an offer from Rudolf Criegee as a lecturer at the Technische Hochschule in Karlsruhe, following his "habilitation" on the topic: "Synthesis and properties of macromolecular complex-forming agents for the selective enrichment of metals". Work on various research projects conceived at Geilweilerhof was now intensified at Karlsruhe. Ernst Bayer investigated complex-forming agents such as glyoxal-bis(2-hydroxyaniline) (GBHA) prepared from *o*-aminophenol (2 mol) and glyoxal (1 mol) (Figure 3), as well as a macromolecular version. As result highly metal-selective polymers for the abstraction of metals such as gold, uranium, and copper from seawater at the Gulf of Naples were developed.

In 1962, Ernst Bayer was invited to be the successor of Heinrich Hellmann as an Associate Professor at the Institute of Organic Chemistry (University of Tübingen). Here he joined a strong chemistry department headed by Eugen Müller (Organic Chemistry), Walter Hückel (Pharmaceutical Chemistry), Gustav Kortüm (Physical Chemistry) and Walter Rüdorff (Inorganic Chemistry). The small medieval university town of Tübingen — famous for alumni including Kepler, Hegel, Hölderlin, Hauff, Mörike and Uhland — provided a stimulating background. It was in Tübingen where Friedrich Miescher isolated for the first time a substance called "nuclein", which contained 30% DNA, in 1869, and where Gerhard Schramm performed the first chemically induced mutation of a nucleic acid in 1952. Motivated by these achievements, Ernst Bayer set up a strong group for natural compound chemistry in Tübingen and at the end of his career he worked on antisense oligonucleotides. His success was always supported by the application of novel analytical techniques. Ernst Bayer acquired the first commercial GC-MS unit in Germany developed by LKB (Sweden), and he identified flavours from rum and hops and fragrances from various brands of cheese. Following the introduction of high performance liquid chromatography (HPLC) in 1967, Ernst Bayer, together with Klaus-Peter Hupe, developed the Micro Adsorption Detector (MAD) as well as designing an HPLC instrument, commercialized by the Hupe & Busch Company in 1968. Fuelled by the growing HPLC market, this company grew and was eventually merged with Hewlett−Packard (now Agilent Technologies), moving to the site at Waldbronn, close to Karlsruhe. Ernst Bayer considered this development as an important early example of "technology transfer" from the university to a start-up company, followed by an expansion in operations to large scale manufacturing.

  

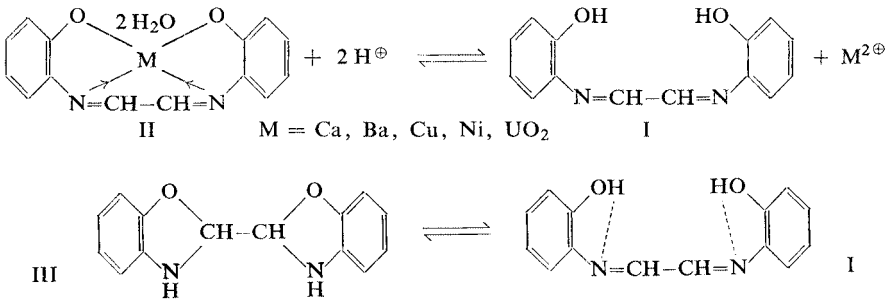


Figure 3. Glyoxal-bis(2-hydroxyaniline) (GBHA) as chelating agent for transition metal ions; top: complexation equilibrium; bottom: oxazoline-hydroxyaniline rearrangement (E. Bayer, G. Schenk, *Chem. Ber.* **1960**, *93*, 1184)

When, in 1966, the Russian scientists Vol'pin and Shur discovered inorganic nitrogen fixation, Ernst Bayer and Volker Schurig decided to investigate the formation of ammonia by the reduction of nitrogen by titanium(IV) compounds using strong reducing agents in tetrahydrofuran. Ernst Bayer's dream, to conduct the Haber–Bosch process at room temperature and normal pressure as a biomimetic process (obviously fostered by associations with Karlsruhe where Fritz Haber worked), is still elusive today. The mechanism of nitrogen fixation in the Vol'pin system was recognized as arising merely from titanium nitride formation. Furthermore, it was discovered that the generation of lithium and magnesium hydride in the presence of molecular hydrogen could be catalyzed by low-valent titanium species. Bayer probably abandoned this topic too early, as it was later shown that the black suspensions obtained by reducing titanium(III) were able to produce olefins from ketones, a transformation which became known as the McMurry reaction (Figure 4).

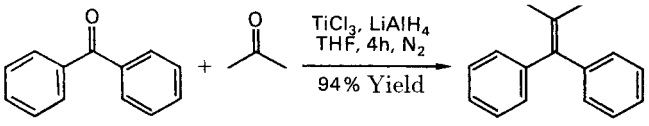


Figure 4. McMurry reaction (1974): reductive coupling of carbonyl compounds to alkenes

Together with Günter Häfelinger, Ernst Bayer also dwelled on the quasiaromatic character of planar metal chelates, in an extension of the work of Hans Musso. Bayer's experiments on the extraction of gold from seawater with selective polymeric resins — revisiting the unsuccessful experiments of Nobel laureate Fritz Haber after World War I in an effort to ease Germany's war debts — was noted in oil-rich Texas and earned him a Robert A. Welch Chair at the University of Houston, USA, in 1967. When Ernst Bayer accepted the offer, he was obliged to commute between Houston and Tübingen on a nearly weekly basis during semesters in order to cope with the teaching demands on both sides of the Atlantic. In Houston, a fruitful co-operation with Albert Zlatkis, (the chairman of as many as 25 international conferences on Advances in Chromatography), resulted.

In 1966, Emanuel Gil-Av (Zimkin) and co-workers of the Weizmann Institute of Science (Israel), described the first separation of enantiomers employing chiral amino acid derivatives as chiral stationary phases by gas chromatography. Following this success, the Manned Spacecraft Center at NASA invited Gil-Av to Texas to determine (with J. Oró) organogenic elements and compounds in lunar materials retrieved by the crew of Apollo 11 from the surface of the Moon, in an effort to find chiral amino acids in extraterrestrial space using the exciting novel tool of enantiomeric analysis (the result turned out to be negative at the nanogram detectability range). In the laboratory of Albert Zlatkis at the University of Houston, Emanuel Gil-Av and Ernst Bayer got to know each other. Since Ernst Bayer was also an established peptide chemist, he supplied some di- and tripeptides to Gil-Av for use as chiral stationary phases in GC studies. The technique of separation of amino acid enantiomers by chiral GC was later considerably broadened by the invention of Hartmut Frank, Graeme Nicholson and Ernst

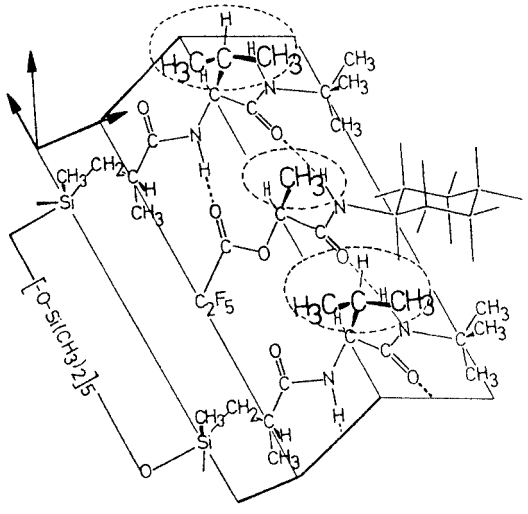

Figure 5. Proposed structure of the molecular associate of the chiral stationary phase Chirasil-Val and *N*-cyclohexyl-*O*-pentafluoropropionyl-L-lactamide (E. Bayer, H. Frank, G. Nicholson, *Angew. Chem. Int. Ed. Engl.* **1978**, *17*, 363)

  

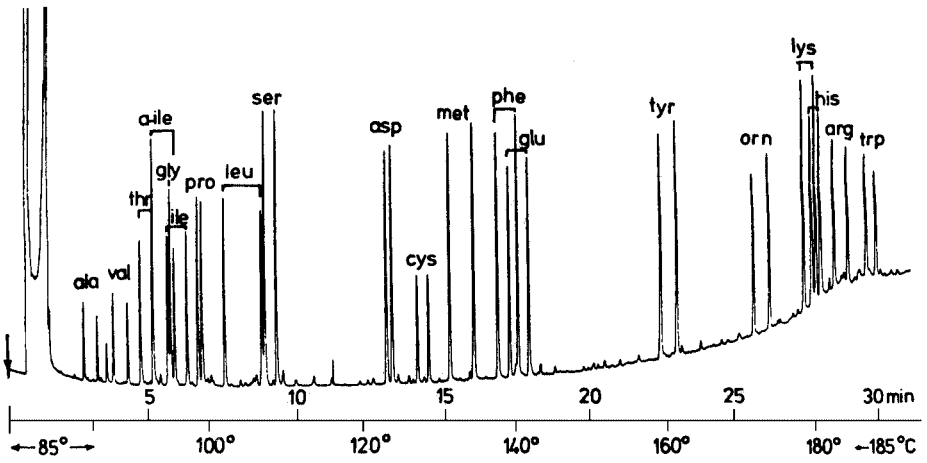


Figure 6. Simultaneous gas-chromatographic enantiomeric separation of 20 proteinogenic amino acids as *N*,*O*,*S*-pentafluoropropionyl/2-propyl esters (histidine as $N^{im}$-ethoxycarbonyl) in 30 min (carrier gas: 40 kPa dihydrogen) with temperature programming; column: 20 m × 0.27 mm (i.d.) Duran glass capillary coated with 0.13 μm Chirasil-Val; D-enantiomers are eluted before L-enantiomers (E. Bayer, *Z. Naturforschung, Teil B* **1983**, *38*, 1281)

Bayer of a synthetic chiral polysiloxane containing valine (named Chirasil-Val) (Figure 5) for hydrogen-bonding racemates. These polymers combined enantioselectivity with the chromatographic efficiency of polysiloxanes, and, using this technique, all 20 proteinogenic amino acids could simultaneously be separated into enantiomers as *N*-TFA-isopropyl esters in less than 25 minutes (Figure 6)!

With this technique, Ernst Bayer determined the extent of amino acid racemization during peptide hydrolysis and peptide synthesis, and he introduced the technique of "enantiomeric labelling" by using the unnatural D-amino acid as an internal standard for the quantification of L-amino acids. Since enantiomers possess strictly the same (nonchiroptical) physical properties in an achiral environment, no errors due to incomplete recovery, fractionation during work-up, sample preparation, chromatographic injection and detection arise. For the development of Chirasil-Val and its application to the study of racemization in peptides and amino acids, Ernst Bayer received in 1981 the Max-Bergmann Medal. Chirasil-Val is now commercially-available both in the L- and D-forms and is used worldwide for the enantiomeric analysis of amino acids and related compounds. The field of enantioselective gas chromatography was later extended to hydrogen-bonding systems by Wilfried König, Hartmut Frank and Bernhard Koppenhöfer, and to chiral coordination compounds by Volker Schurig.

In Houston, Ernst Bayer also continued his work on metal-binding polymers, metalloproteins and the Merrifield solid-phase peptide synthesis. The hormone oxytocin and the polypeptide apoferrodoxin were prepared by Günther Jung and Hanspaul Hagenmaier and their purity determined by the methods (e.g. HPLC and GC-MS) which Ernst Bayer and others had previously developed.

In 1971, Ernst Bayer was back in Tübingen on a permanent basis, holding the second Chair of Organic Chemistry. When his elderly colleagues retired, Ernst Bayer became director of the Chemistry department and he was very successful in setting up a modern and growing institute in the modern buildings of the newly-established science campus of Tübingen by a steady expansion in personnel, resources and instrumentation. Together with Günther Jung and Hanspaul Hagenmaier, Ernst Bayer embarked further on peptide synthesis and amino acid analysis, and with Wolfgang Voelter on carbohydrates. NMR spectroscopic techniques were applied to peptide research together with Eberhard Breitmaier, and to mass spectrometry with Wilfried König. From 1974, he investigated selective peptide-nucleotide interactions (with Herbert Schott and Heiner Eckstein) using a technique known as Template Chromatography. This method utilizes oligonucleotides anchored to DEAF cellulose as selective stationary phase for protein interaction. In 1976, Ernst Bayer and Edgar Grom separated dansylated amino acids by HPLC in the femtomole range using fluorescence detection. He worked on the active constituent of peptide antibiotics from *Streptomycetes* called phosphinotricin (Figure 7), which carries a stereogenic phosphorus atom in the amino acid L-glufosinate [(*S*)-2-amino-4-(hydroxymethylphosphinoyl)-butyric acid]. This compound is used commercially (in the form of the racemic ammonium salt), as the herbicide BASTA. He elucidated the structure both of amavadin (Figure 8) a vanadium compound first isolated from the toadstool mushroom *Amanita muscaria* by Helmut Kneifel, and hemerythrin.

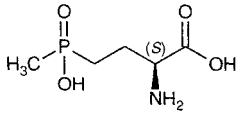


Figure 7. Structure of phosphinothricin [(5)-2-amino-4-(hydroxymethylphosphinoyl)butanoic acid (L-Glufosinate)] (E. Bayer, *Z. Naturforschung, Teil B* **1983**, *38*, 1281)

  

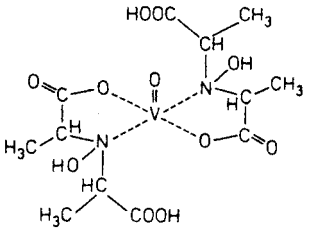

Figure 8. Structure of amavadin, a vanadium compound found in nature (E. Bayer, E. Koch, G. Anderegg, *Angew. Chem.* **1987**, *99*, 570); a revised structure with complexed carboxylic acid groups has also been proposed

Other investigations were concerned with morulin, tunichromes and various humic compounds. The latter investigations initiated Bayer's work on the conversion of biomass into oil. This contribution of Ernst Bayer to environmental research was spurred by the recognition that oil originates from the degradation of biomass under mild conditions, and that catalysts must have been involved in such a conversion. His studies on the conversion of lipid- and peptide-rich biomass to oil verified this assumption and demonstrated that the time scale for such transformations can be reduced from aeons to a few hours in the laboratory at ambient temperature. As a catalyst for this process, the residue of extracted oil shale found south of Tübingen was used. Again, by the in-house availability of refined analytic tools Ernst Bayer demonstrated the absence of toxic side products such as polyaromatic hydrocarbons, organochlorines, dibenzoxines and dibenzofurans from the derived oils. The process of converting sludge into diesel-like fuel was extended to use biomass, such as agricultural or domestic waste, on a commercial scale., Such plants, preferentially located at waste-water treatment sites, are planned for operation in the near future in Germany, Australia and Brazil, where the waste from the sugar cane industry will be utilized.

Despite his enormous strategic and tactical talent, Ernst Bayer was not entirely successful in implementing his apparently alchemistic concept to produce "black gold from bullshit" — as some called it — into a worldwide production line, due to rivalries between sponsors and entrepreneurs and battles with competitors and monopolists (as Ernst Bayer himself frequently complained). Nevertheless, for the development of this catalytic, biomimetic process to convert biomass and sludge into a petroleum-like oil Ernst Bayer received the Philip Morris Research Prize "Men and Environment" in 1985.

Using chromatographic methods, Ernst Bayer soon recognized that the solid-phase peptide synthesis of Merrifield (Figure 9) suffers from the formation of incorrect sequences if the coupling steps proceed with less than 100% yield. With a 95% yield for every protection and deprotection step, the theoretical yield of a 30-mer polypeptide is as small as 4.7%. Therefore, Manfred Mutter and Ernst Bayer invented the method of Liquid Phase Peptide Synthesis using poly(ethylene glycol) as a soluble polymeric carrier, allowing chromatographic methods for peptide screening in solution (Figure 9 and 10). This method was later extended with Wolfgang Rapp to grafted copolymers of polystyrene-poly(ethylene glycol). These polymers, called tentagels, were also prepared as beads and were commercialized by Rapp-polymers and thus used worldwide as carriers in peptide, oligonucleotide and combinatorial chemistry. In all these endeavours, once again methodology, development and innovative analytical screening were going hand-in-hand.

Based on the concept of the use of soluble polymers as carriers for synthesis, in 1976 Ernst Bayer and Volker Schurig extended this approach to homogeneous catalysis by transition metals. Triphenylphosphane-modified linear polystyrene was used as a soluble polymeric ligand for Wilkinson-type rhodium catalysts and used for the hydrogenation and hydroformylation of olefins in organic solvents using a membrane filtration reactor. Whereas the products permeate the membrane, the soluble polymeric catalyst does not and is thus quantitatively retained, allowing a continuous homogeneous catalytic process (Figure 11). Also, in the same year, the asymmetric hydroformylation of styrene using a soluble polymeric support containing Kagan's chiral diphosphane ligand Diop was first attempted. The concept of soluble polymeric homogeneous catalysts and separation of the products from the catalyst by precipitation or membrane techniques received renewed attention more recently. In collaboration with Kurt Geckler, soluble polymers containing metal-binding chelating groups were also utilized to separate metal ions, according to their binding affinity, in a continuous membrane filtration unit. Metal-assisted reversible oxygenations also aroused the interest of Ernst Bayer. A synthetic model hemopolymer for the reversible binding of dioxygen was devised by Ernst Bayer and Gunter Holzbach (Figure 12).

After 1977, Ernst Bayer and Klaus Albert, together with the NMR company Bruker Physics, investigated the on-line coupling of HPLC with capillary electrophoresis and NMR spectroscopy using continuous flow cells (Figure 13). Together with Professor Georges Guiochon, $^{29}Si$- and $^{13}C$ cross-polarization and magic angle spinning (MAS) solid state NMR spectroscopy was employed for the in-column characterization of the structures of reversed phases for HPLC, including studies on dynamic phenomena of *n*-alkanes. This work helped the understanding of retention mechanisms in reversed-phase HPLC. Imaging NMR was another technique used to gain information on dispersion effects and of bed homogeneity in HPLC columns. When, in 1989, the electrospray technique was introduced, Tübingen received the first commercial instrument (Sciex API III) in Europe for the coupling of liquid chromatography and mass spectrometry (LC-MS).

Even after his retirement in 1994 and still enjoying good health, Ernst Bayer started a new career as head of a newly created Center of Peptide and Nucleotide Chemistry at the University of Tübingen, and he continued to lead the Graduate College for Analytical Chemistry with his deepest devotion to the education of the younger generation.

  

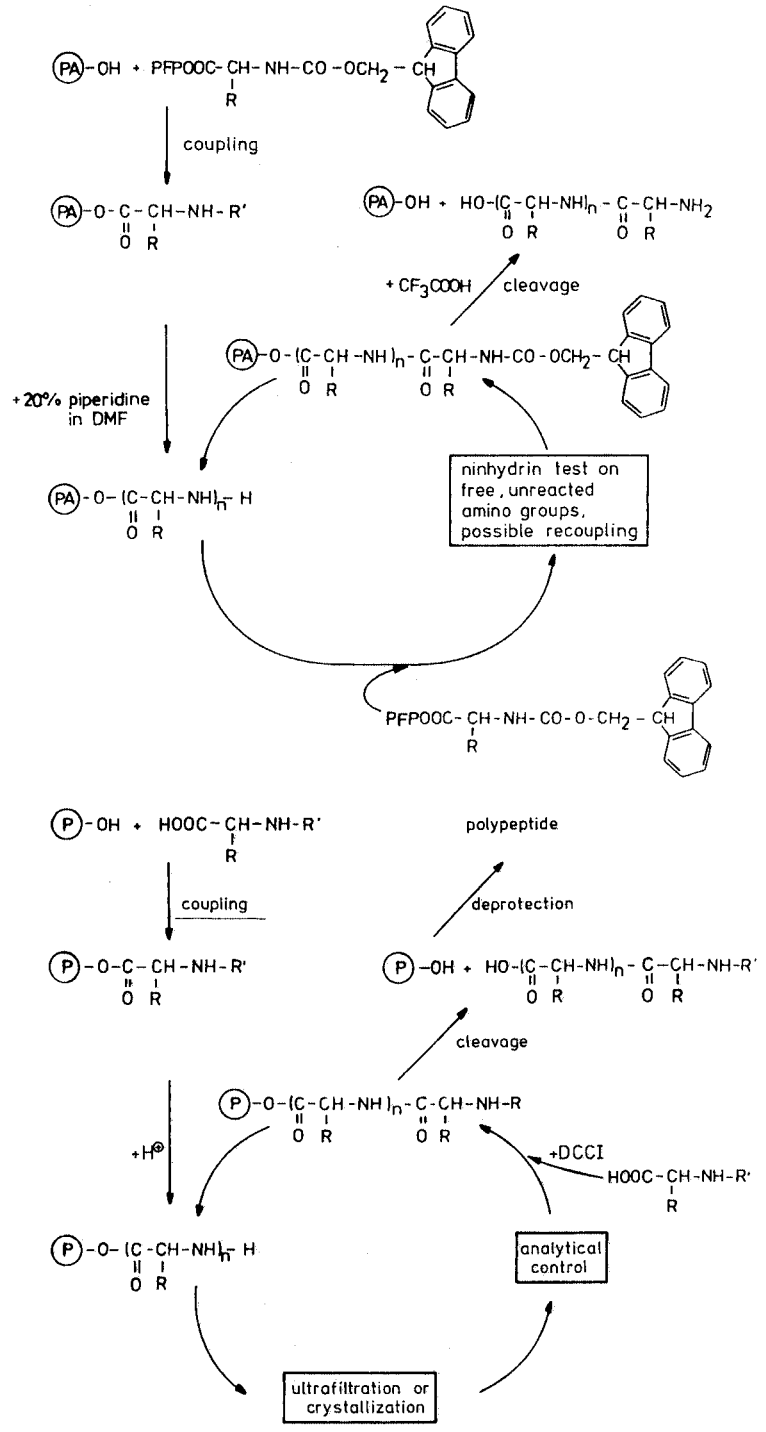


Figure 9. Peptide synthesis; top: standard cycle for the Merrifield solid-phase peptide synthesis using the Fmoc strategy; bottom: standard cycle for the liquid phase peptide synthesis (E. Bayer, *Angew. Chem. Int. Ed.* **1991**, *30*, 113)

Released from the burden of administrative and public commitments, Ernst Bayer concentrated on research into miniaturizing capillary HPLC, capillary electrophoresis (CE) and capillary electrochromatography (CEC) methods, as well as hyphenation via coupling to MS and NMR and unified approaches (LC, CEC) under gradient conditions. In the mass spectrometric field, a new electrospray technique named coordination ionspray (CIS-MS) was discovered. This is based on the addition of charged metal coordination compounds which selectively complex unsaturated fatty acids, saccharides, protected peptides and many other analytes with suitable functional groups, rendering ionization by physical impact or electric fields unneccessary. Using the two dimensional MS-MS technique, further information was gained from novel fragmentation patterns of complexed analytes, thus

  

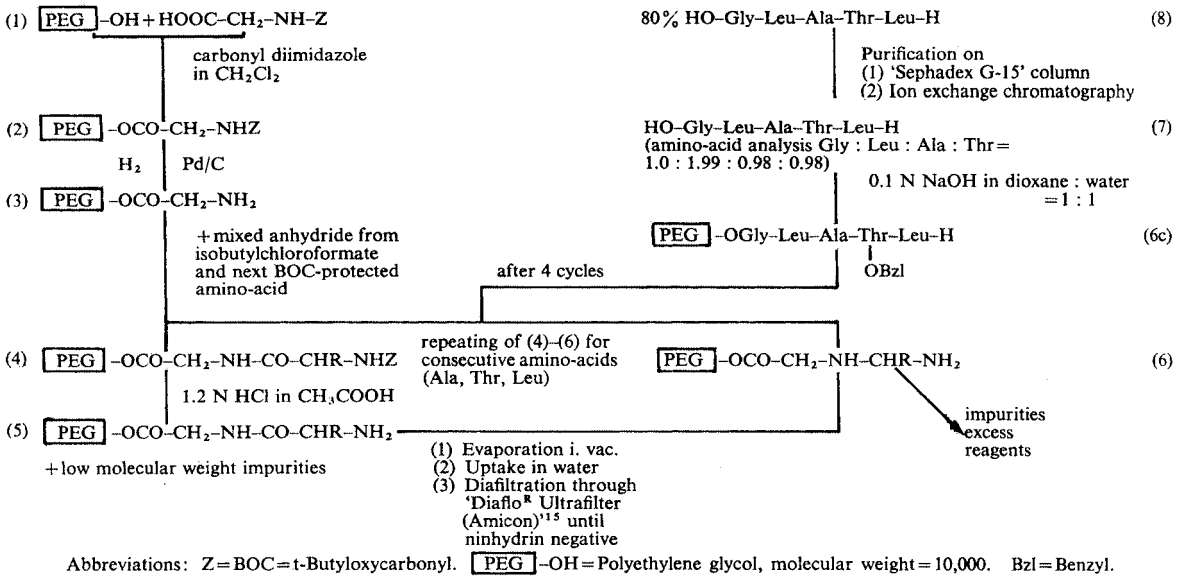


Figure 10. Flow chart for the synthesis of HO-Gly-Leu-Ala-Thr-Leu after the liquid phase method (E. Bayer, M. Mutter, *Nature* **1972**, *237*, 512)

Figure 11. Membrane filtration cell adopted to an organic medium (benzene) for a continuous homogeneous hydrogenation of alkenes utilizing a soluble polystyrene-bonded Wilkinson-type catalyst; the polymeric yellow catalyst is trapped in the retendate while the product passes the membrane into the filtrate (V. Schurig, E. Bayer, *Chem. Tech.* **1976**, *6*, 212)

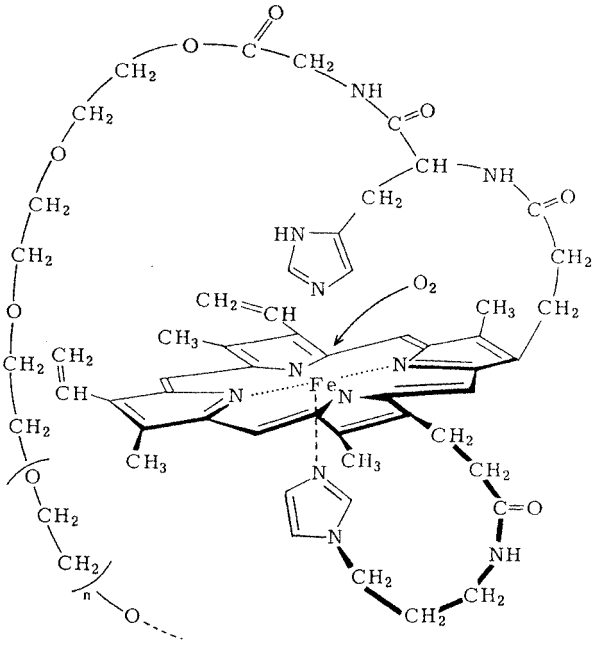

Figure 12. A synthetic hemopolymer for the reversible binding of dioxygen (E. Bayer, G. Holzbach, *Angew. Chem. Int. Ed. Engl.* **1977**, *16*, 117)

facilitating structural investigations. Ernst Bayer also developed charged nanoparticles for the selective extraction of oligonucleotides from biological matrices and he embarked on the synthesis of antisense oligonucleotides.

As a consequence of his outgoing and open-minded personality and his unconventional style in selecting modern topics of research, Ernst Bayer attracted approximately 220 Ph.D. students and many postdoctoral fellows. Twenty-four of his former coworkers received

  

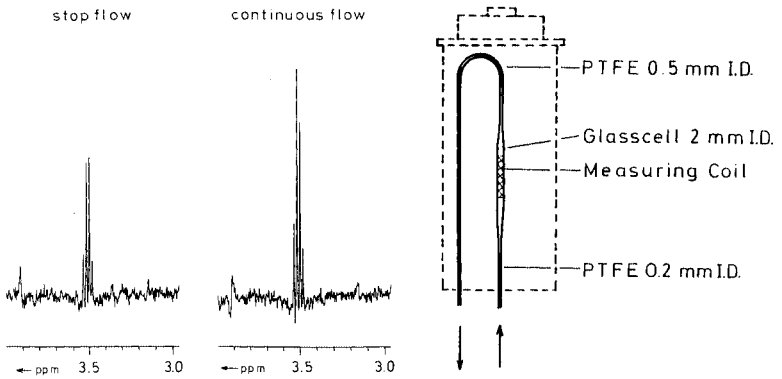


Figure 13. High-performance liquid chromatography−nuclear magnetic resonance on-line coupling (HPLC-NMR); left: stop-flow and continuous-flow $^1$H-NMR spectrum (400 MHz) of the methylene protons of ethanol (flow: 2.4 mL/min); right: continuous-flow cell measurement arrangement (K. Albert, E. Bayer, *Trends Anal. Chem.* **1988**, *7*, 288)

professorships in different fields of chemistry, reflecting Ernst Bayer's broad spectrum of interests. As a mentor, Ernst Bayer gave his scientific offspring absolute freedom within their research pursuits. Success was almost guaranteed due to the judicious choice of promising research topics, often selected by instinctive foresight. The projects were mostly loosely defined and when success was realized, Ernst Bayer was quick to exploit the novel findings, as reflected by his list of about 100 patents. Many spin-off companies were founded by former co-workers, and these developed chromatographic equipment such as amino acid analyzers, column packings, chiral stationary phases, resins, and chemicals for peptide and oligonucleotide production and pollution control.

Ernst Bayer had an uncanny abilty to prophesize chemical trends. This foresight guided him reliably along the winning path and spared him from potential failures. He also had a remarkable gift of rapid perception and an enormous knowledge of a broad spectrum of chemistry at his disposal. Since he could not possibly absorb the vast flood of information from the literature, he probably, apart from plain intuition, grasped facts and trends mainly at international meetings and conferences which he attended as frequently as possible (in fact the scientific discussions with his coworkers often took place abroad rather than in the institute at home). As a constant learner, he attended almost every lecture across a range of fields of chemistry at Tübingen. Occasionally, seemingly exhausted from a hard day's work, Ernst Bayer could appear to others in the lecture theatre to be rather absent-minded (if not to say asleep). Yet his critical and constructive questions after the presentation pointing sharply at the essence of the lecture topic proved that he had indeed been alert the whole time. When Ernst Bayer planned far-reaching steps, he did not follow a single path but approached the goal from many directions. This multidimensional approach of thinking and decision-making helped him *inter alia* to create one of the largest departments of organic chemistry in Germany.

When mainland China opened its borders, Ernst Bayer was one of the first to establish firm scientific links with institutes in Dalian. The co-operation with East-European countries, including former East Germany, was very intense and close links existed with Brazil on environmental matters. Ernst Bayer's extensive cooperation with foreign countries is reflected by his intake of 35 foreign Ph.D. students, 35 foreign postdoctoral fellows and 31 visiting professors. Ernst Bayer was a member of the editorial board of many scientific journals and science commissions. He was a member of the IUPAC analytical chemistry nomenclature commission and a member of a number of committees of scientific congresses, as well as chairman or co-chairman of numerous conferences and symposia held at Tübingen University, examples of which are the Peptide Symposia, Membrane Separation Technique Symposia and the Chiral Discrimination Symposium. Ernst Bayer also founded the European Membrane Society, and during the cold war he also initiated the German-Russian Peptide symposia. At Tübingen University he developed curricula in toxicology and initiated "technology transfer" departments.

The scientific work of Ernst Bayer was recognized with many honours for his research in very different areas (see Addenda). For his research in structure elucidation of metal proteins and antibiotics, he received the medal of the German Chemical Society, named after his former teacher Richard Kuhn, in 1990. In 1994 he received the Fresenius Prize of the German Chemical Society for his contributions to analytical chemistry and in 2000 the M. J. E. Golay Award in Capillary Chromatography for his contributions to capillary HPLC, capillary electrochromatography and hyphenated techniques. In addition to his scientific activities, Ernst Bayer was also deeply involved in administrative and policy matters, serving at various times as Dean of the Faculty, as President of the Senate and as Vice-President of Tübingen University. He was also Vice President of the German Chemical Society (GDCh), Head of the Chromatography Section of the GDCh and Head of the Advisory Committee for Environmentally-Relevant Chemicals of the GDCh. In this latter commission, Ernst Bayer and associates screened over 1200 critical substances

  

and proposed their regulation by the German government and recently by the European Commission.

Ernst Bayer was a steadfast and eminent cultured man with strong interests in politics, travel and art. He was a lucid entertainer drawing from a plethora of anecdotes and events. After his professorship at the University of Houston, he collected Aztec artefacts.. He had strong associations with Italy, where he carried out early work on tunicates and extraction of gold from sea water at the Gulf of Naples. He frequently spent vacations in Italy at his summer residence close to Triest. Despite his workload he was sincerely dedicated to his family and he cared deeply for his five children. In return he received strong support from his family in order to succeed in the outside world. Although keeping a certain distance in private matters, this did not prevent Ernst Bayer from assembling the large family clan, together with a large crowd of former and present coworkers, when his 60th, 65th and 70th birthdays were celebrated. Due to his broad interests and achievements in chemistry, Ernst Bayer enjoyed the acquaintance and friendship of a large number of scientists around the world, and he was highly respected by the scientific community.

A doyen of chromatography and of natural compound chemistry has gone. Ernst Bayer left the scientific arena at the time when stagnation began creeping into both academia and industry, in strong contrast to the situation when he started his career. His valuable and broad contribution to chemistry, his knowledge, wisdom, and advice will be sorely missed.

In memory of Ernst Bayer, the working group of Separation Science of the German Chemical Society (GDCh) has inaugurated the Ernst-Bayer-Prize for young scientists.

## Addenda

**Prizes Bestowed upon Ernst Bayer**

**1978**: A. J. P. Martin Award
**1978**: M. S. Tswett Chromatography Memorial Medal of the USSR Academy of Sciences
**1981**: British Petroleum Energy Research Prize
**1981**: Max Bergmann Medal
**1985**: Philip Morris Research Prize "Men and Environment"
**1986**: M. S. Tswett Chromatography Award
**1989**: First Class Merit Cross of the Federal Republic of Germany
**1990**: International Rheinland-Prize for Environmental Protection
**1990**: Richard Kuhn Medal of the German Chemical Society
**1993**: Fritz Pregl Medal of the Analytical Chemistry Society of Austria
**1994**: Fresenius Prize of the German Chemical Society
**1994**: Grand Merit Cross of the Federal Republic of Germany
**1997**: Maria Sklodowska Curie Medal of the Polish Chemical Society
**2000**: M. J. E. Golay Award in Capillary Chromatography
**2000**: I. Hala'sz Medal of the Hungarian Society
**2001**: American Chemical Society National Award in Chromatography

**Professors Emerging from Ernst Bayer's Research Group (in alphabetical order)**

Klaus Albert (Tübingen), Somaya Abdel Rahman (Zagazi, Egypt), Klaus Beyer (München), Franz Brandsteher (Ludwigshafen), Eberhard Breitmaier (Bonn), Heiner Eckstein (Tübingen), Hartmut Frank (Bayreuth), Kurt Geckeler (Korea), Helmut Grüb (Holzminden), Günter Häfelinger (Tübingen), Hanspaul Hagenmaier (Tübingen), Walter Jäger (Tübingen), Günther Jung (Tübingen), Helmut Kneifel (Jülich), Wilfried König (Hamburg), Bernhard Koppenhöfer (Tübingen), Peter Krauss (Tübingen), Hartmut Liebich (Tübingen), Manfred Mutter (Lausanne), Oskar Oster (Kiel), Holm Pauschmann (Tübingen), Herbert Schott (Tübingen), Volker Schurig (Tübingen), Wolfgang Voelter (Tübingen).

**Published Obituaries**

G. Häfelinger, *Nachr. Chem. Techn.* **2002**, *50*, 507.
G. Guiochon, *J. Chromatogr. A* **2002**, *954*, 1−4.
J. Sliwiok, *Acta Chromatogr.* **2002**, *12*, U7.
H. Frank, *J. Sep. Sci.* **2002**, *25*, 466−467.
V. Schurig, *Chromatographia* **2002**, *55*, 397−398.

## Acknowledgments

Many thanks are due to Graeme Nicholson, Günther Jung, and Günter Häfelinger for helpful advice. The compilation and typing of the comprehensive list of E. Bayer's publications by his last secretary, Mrs. Inge R. Straub, is acknowledged with great thanks.

*V. Schurig (Tübingen)*

  

Table 1. Comprehensive list of publications of Ernst Bayer

| Entry | Authors | Title | Journal | Year | Volume | Page |
|---|---|---|---|---|---|---|
| 1 | H. J. Bielig, E. Bayer | Über die angebliche *cis-trans*-Isomerie beim Eisen(II)-Komplex der Chinaldinsäure. | Naturwiss. | 1953 | 40 | 340 |
| 2 | E. Bayer, H. J. Bielig, K. H. Hausser | Magnetochemische Untersuchungen an Innerkomplexen des Vanadiums und an deren Komplexbildnern. | Liebigs Ann. Chem. | 1953 | 584 | 116 |
| 3 | H. J. Bielig, E. Bayer | Anionische, neutrale und cationische Großringkomplexe des 3-, 4- und 5-wertigen Vanadiums. (Untersuchungen über Hämovanadin, I) | Liebigs Ann. Chem. | 1953 | 580 | 135 |
| 4 | H. J. Bielig, E. Bayer | Über die Molekulargröße des Hämovanadins. (Untersuchungen über den vanadiumhaltigen Blutfarbstoff, III). | Experientia | 1954 | 10 | 300 |
| 5 | H. J. Bielig, E. Bayer; L. Califano, L. Wirth | Hämovanadin, ein Sulfato-Komplex des 3-wertigen Vanadiums. (Untersuchungen über den vanadiumhaltigen Blutfarbstoff, II) | Publ. Staz. Zool. Napoli | 1955 | 25 | 26 |
| 6 | H. J. Bielig, E. Bayer | Synthetisches Ferritin, ein Eisen(III)-komplex des Apoferritins. | Naturwiss. | 1955 | 42 | 125 |
| 7 | E. Bayer, K. H. Hausser | Eisen(III)-komplexe mit 3 ungepaarten Elektronen. | Experientia | 1955 | 11 | 254 |
| 8 | H. J. Bielig, E. Bayer | Eisenaustausch zwischen Proteinen: Modellversuche zur Eisenresorption und -speicherung im Tierkörper. | Naturwiss. | 1955 | 42 | 466 |
| 9 | E. Bayer | Magnetochemische Untersuchungen an Koordinationsverbindungen des Vanadiums und Eisens. | Angew. Chem. | 1955 | 67 | 521 |
| 10 | H. J. Bielig, E. Bayer | Koordinationsverbindungen von 3-wertigem Eisen mit Aminosäuren. | Chem. Ber. | 1955 | 88 | 1158 |
| 11 | E. Bayer, K. H. Reuther | Photometrische Mikrobestimmung von Acylgruppen. Analytische Verwendung von Eisen(III)-hydroxamsäurekomplexen. | Chem. Ber. | 1956 | 89 | 2541 |
| 12 | E. Bayer | Biologische und chemische Wege zur Anreicherung von Spurenelementen. | Experientia | 1956 | 12 | 365 |
| 13 | E. Bayer, K. H. Reuther | Papierchromatographische Analyse von Carbonsäureestergemischen sowie deren Anwendung zur Untersuchung von Aromastoffen. | Angew. Chem. | 1956 | 68 | 698 |
| 14 | E. Bayer | Die spezifische Bindung von Schwermetallionen an hoch- und niedermolekulare Schiffsche Basen. | Angew. Chem. | 1957 | 69 | 107 |
| 15 | E. Bayer, K. Wegmann | Enzymatischer Abbau von Anthocyanen. | Z. Naturforschung | 1957 | 12b | 37 |
| 16 | H. J. Bielig, E. Bayer | Austausch- und Abbauversuche am Hämovanadin. (Untersuchungen über den vanadiumhaltigen Blutfarbstoff, IV) | Publ. Staz. Zool. Napoli | 1957 | 29 | 109 |
| 17 | E. Bayer, F. Born, K. Reuther | Über die Polyphenoloxydase der Trauben. | Z. Lebensmittelunters. Forschung | 1957 | 105 | 77 |
| 18 | E. Bayer | Aromastoffe des Weines I. Die Carbonsäureester des Weines und der Trauben. | Vitis | 1957 | 1 | 34 |
| 19 | E. Bayer | Aromastoffe des Weines II. Aliphatische Aldehyde des Weines und der Trauben. | Vitis | 1957 | 1 | 93 |
| 20 | E. Bayer, K. H. Reuther, R. Ter | Photometrische Mikrobestimmung und papierchromatographischer Nachweis von Aldehyden. | Chem. Ber. | 1957 | 90 | 1929 |
| 21 | E. Bayer | Metallkomplexe Schiffscher Basen aus o-Aminophenol und Dicarbonylverbindungen. | Chem. Ber. | 1957 | 90 | 2325 |
| 22 | E. Bayer | Synthese makromolekularer Komplexbildner aus Aminophenolen und Glyoxal. | Chem. Ber. | 1957 | 90 | 2785 |
| 23 | E. Bayer, K. H. Reuther, F. Born | Analyse von Aminosäure-Gemischen mittels Gas-Verteilungschromatographie. | Angew. Chem. | 1957 | 69 | 640 |
| 24 | E. Bayer | Gas-Verteilungschromatographie bei höheren Temperaturen. | Angew. Chem. | 1957 | 69 | 732 |
| 25 | E. Bayer | Separation of derivatives of amino acids using gas-liquid chromatography | *Gas Chromatography,* (Ed. Desty), Butterworths Scientific Publ., London | 1958 | | 333 |
| 26 | E. Bayer, G. Kupfer, K. H. Reuther | Anwendung der Gas-Chromatographie zur Analyse künstlicher und natürlicher Aromastoffe. | Z. Anal. Chem. | 1961 | 52 | 103 |
| 27 | E. Bayer | Über den blauen Farbstoff der Kornblume I. | Chem. Ber. | 1958 | 91 | 1115 |
| 28 | E. Bayer | Anwendung chromatographischer Methoden zur Qualitätsbeurteilung von Weinen und Mosten | Vitis | 1958 | 1 | 298 |
| 29 | E. Bayer, H. Möllinger | Mikrobestimmung, selektive Abtrennung und Anreicherung von Uran mittels Schiffscher Basen. | Angew. Chem. | 1959 | 71 | 426 |
| 30 | E. Bayer | Selektivität der flüssigen Phase bei der Gasverteilungs-chromatographie und Wahl der Trägersubstanz. | Angew. Chem. | 1959 | 71 | 299 |
| 31 | E. Bayer | Farbstoffe der roten, blauen und violetten Lupinenblüten. Über Anthocyankomplexe II. | Chem. Ber. | 1959 | 92 | 1062 |
| 32 | E. Bayer, F. Anders | Biologische Objekte als Detektoren zur Gaschromatographie. | Naturwiss. | 1959 | 46 | 380 |

  

Table 1. *(continued)*

| Entry | Authors | Title | Journal | Year | Volume | Page |
|---|---|---|---|---|---|---|
| 33 | F. Anders, E. Bayer | Versuche mit dem Sexualduftstoff aus den Sacculi laterales vom Seidenspinner. | Biol. Zentralbl. | 1959 | 78 | 584 |
| 34 | E. Bayer, H. G. Witsch | Präparative Gaschromatographie, I. Mitteilung | Z. Anal. Chem. | 1959 | 170 | 278 |
| 35 | E. Bayer | Natürliche und synthesische Anthocyankomplexe. | Angew. Chem. | 1959 | 71 | 374 |
| 36 | E. Bayer, H. Röck | Zur thermodynamischen Charakterisierung der Selektivität in der Gas-Chromatographie. | Angew. Chem. | 1959 | 71 | 407 |
| 37 | H. J. Bielig, E. Bayer | Metallproteide und verwandte Systeme. | *Handbuch der physiologisch- und pathologisch-chemischen Analyse*, (10th Ed.), Hoppe-Seyler/Thierfelder. | 1060 | 4 | 714 |
| 38 | E. Bayer, G. Schenk | Umlagerung organischer Komplexbildner und Spezifität der Komplexbildung. | Chem. Ber. | 1960 | 93 | 1184 |
| 39 | E. Bayer | Neuere Entwicklung der Gas-Chromatographie. | Naturwiss. | 1960 | 47 | 43 |
| 40 | E. Bayer | Strukturelemente stickstoffhaltiger organischer Chelatbildner. | Angew. Chem. | 1960 | 72 | 566 |
| 41 | E. Bayer, K. Nether, H. Egeter | Synthese der blauen, im Kornblumenfarbstoff enthaltenen Chelate. | Chem. Ber. | 1960 | 93 | 2871 |
| 42 | E. Bayer, H. Fiedler | Makromolekulare organische Komplexbildner zur Anreicherung von Uran und Kupfer aus Meerwasser. | Angew. Chem. | 1960 | 72 | 921 |
| 43 | E. Bayer, G. Wahl, H. G. Witsch | Präparative Gas-Chromatographie, II. Mitteilung. | Z. Anal. Chem: | 1961 | 181 | 321 |
| 44 | E. Bayer | Gas-Chromatography, Monography, bearbeitet und erweitert nach der deutschen Ausgabe. | Elsevier, Amsterdam | 1961 | | 240 |
| 45 | E. Bayer, K. P. Hupe | Präparative Gas-Chromatographie, III. Mitteilung | Angew. Chem. | 1961 | 73 | 525 |
| 46 | E. Bayer, L. Bäßler | Identifizierung von Estern im Weinaroma. | Z. Anal. Chem. | 1961 | 181 | 418 |
| 47 | E. Bayer | Aromatenähnliche Eigenschaften bei Chelaten. | Angew. Chem. | 1961 | 73 | 533 |
| 48 | E. Bayer | Struktur und Spezifität bei natürlichen und synthesischen organischen Komplexbildnern. Synthesen, Eigenschaften, Anwendung makromolekulare Komplexbildner in | *Anomalien bei Ionenaustauschern*, R. Wolff, Akademie-Verlag, Berlin | 1961 | 73 | 659 |
| 49 | E. Bayer, R. Widder | Darstellung isomerer Zuckeräther. | Angew. Chem. | 1961 | 73 | 766 |
| 50 | E. Bayer | Präparative Gas-Chromatographie | Gas-Chromatographie, Akademie-Verlag, Berlin | 1961, 1962 | | |
| 51 | E. Bayer, H. Fiedler | Über den Aufbau des Hämocyanins. | Liebigs Ann. Chem. | 1962 | 653 | 149 |
| 52 | E. Bayer | In der Natur vorkommende Metallkomplexe. | Chimia | 1962 | 16 | 333 |
| 53 | E. Bayer | Monographie "Gas-Chromatographie" 2. völlig neu bearbeitete, erweiterte Auflage. | Springer-Verlag, Heidelberg | 1962 | | |
| 54 | E. Bayer, H. A. Brune, K. L. Hock | Synthese von Ferrolderivaten. | Angew. Chem. | 1962 | 74 | 872 |
| 55 | E. Bayer, K. P. Hupe, H. Mack | Filling of Analytical and Preparative Columns for Gas Chromatography. | Anal. Chem | 1963 | 35 | 492 |
| 56 | E. Bayer | Präparative Gas-Chromatographie. | Chimia | 1963 | 17 | 199 |
| 57 | F. Schmidt, E. Bayer | Metallalcohol, -phenolate, -enolate, −chelate. , | *Methoden der Organischen Chemie*, Houben-Weyl-Müller, Verlag Thieme, Stuttgart | 1963 | IV/2 | 1 |
| 58 | E. Bayer | Synthese und Eigenschaften substituierter Diflavylene und Quercetylene. | Angew. Chem. | 1963 | 75 | 1124 |
| 59 | E. Bayer | Struktur und Spezifität organischer Komplexbildner. | Angew. Chem.. | 1964 | 76 | 76 |
| | | | Angew. Chem., Int Ed. Engl. | 1964 | 3 | 325 |
| 60 | E. Bayer, B. Krämer | Synthese von Quercetylenderivaten | Chem. Ber. | 1964 | 97 | 1057 |
| 61 | E. Bayer, Müller, B. Krämer, K. Scheffler | Über den Piezomagnetismus der Diflavenylidene. | Tetrahedron Lett. | 1964 | 35 | 2403 |
| 62 | E. Bayer | Apparatus for Large Scale Gas Chromatography. | J. Chem. Educ. | 1964 | 41A | 755 |
| 63 | G. Häfelinger, E. Bayer | Struktur-Isomere bei Kobalt-Chelaten von 2-Hydroxyazobenzolen. | Naturwiss. | 1964 | 51 | 136 |
| 64 | E. Bayer, R. Widder | Gas-Chromatographic Determination of the Carbonylforms of Sugars. | Anal. Chem. | 1964 | 36 | 145 |
| 65 | E. Bayer | Gas-Chromatographie in der Biochemie in | *Biochemisches Taschenbuch*, H. Rauen, Springer-Verlag, Heidelberg. | 1964 | II | 892 |
| 66 | E. Bayer, W. Voelter | Natürliche Farbstoffe mit Ausnahme von Myo- und Hämoglobin. Handbuch der Lebensmittelchemie I. S. | Springer-Verlag, Heidelberg | 1965 | | 649 |
| 67 | K. P. Hupe, E. Bayer | Temperature Distribution in Temperature Programmed Columns. A. Goldup Gas Chromatograühy 1964 | Institute of Petroleum, London | 1965 | | 6276 |
| 68 | E. Bayer, W. Parr, B. Kazmaier | Über den Aufbau des Ferredoxins, des Wirkstoffes der Assimilationsvorgänge. | Archiv Pharmazie | 1965 | 298 | 196 |
| 69 | E. Bayer, R. Widder | Gaschromatographische Untersuchung der verschiedenen Ringformen in Lösungen von Monosacchariden. | Liebigs Ann. Chem. | 1965 | 686 | 181 |
| 70 | E. Bayer, R. Widder | Über die Carbonylform der Zucker. | Liebigs Ann. Chem. | 1965 | 686 | 197 |
| 71 | E. Bayer | Über das Aroma des Weines. | Attempto, Tübingen | 1965 | 15 | 24 |
| 72 | E. Bayer | Quality and Flavor by Gas Chromatography. | J. Gas Chromatogr. | 1966 | 1966 | 67 |
| 73 | E. Bayer, W. Voelter | Preparation of iron free active xanthine oxidase. | Biochim. Biophys. Acta | 1966 | 113 | 632 |

  

Table 1. *(continued)*

| Entry | Authors | Title | Journal | Year | Volume | Page |
|---|---|---|---|---|---|---|
| 74 | E. Bayer, G. Häfelinger | Bestimmung der MO-π-Bindungsordnung von Chelat-ringen mit zwei konjugierten CN-Doppelbindungen. | Chem. Ber. | 1966 | 99 | 1689 |
| 75 | E. Bayer, E. Breitmaier | Die Reaktion von Benzil mit 2-Aminothiophenol. | Tetrahedron Lett. | 1966 | 15 | 1689 |
| 76 | E. Bayer, W. Voelter | Molybdat-Komplexe von Zuckern und Polyalcoholn. | Liebigs Ann. Chem. | 1966 | 696 | 194 |
| 77 | E. Bayer | Aromatischer Charakter bei Chelaten. | Nachrichten aus Chemie und Technik | 1966 | 1966 | 303 |
| 78 | E. Bayer, W. Parr | Eliminierung von Schwefelwasserstoff aus Ferredoxin und Cysteinmethylester. | Angew. Chem. | 1966 | 78 | 824 |
| | | | Angew. Chem., Int. Ed. Engl. | 1966 | 5 | 840 |
| 79 | E. Bayer | Komplexbildung und Blütenfarben. | Angew. Chem. | 1966 | 78 | 834 |
| | | | Angew. Chem., Int. Ed. Engl. | 1966 | 5 | 791 |
| 80 | A. Röder, E. Bayer | Untersuchungen an Modellkomplexen für Nicht-Häm-Eisenproteide. | Angew. Chem. | 1967 | 79 | 274 |
| 81 | K. P. Hupe, E. Bayer | A Micro Adsorption Detector for General Use in Liquid Chromatography. | J. Gas Chromatogr. | 1967 | 5 | 197 |
| 82 | E. Bayer, P. Schretzmann | Reversible Oxygenierung von Metallkomplexen. | Structure and Bonding | 1967 | 2 | 181 |
| 83 | E. Bayer, D. Josef, P. Krauß, H. Hagenmaier, A. Röder, A. Trebst | Abbau und Resynthese des Aktivzentrums von Pflanzenferredoxin. | Biochim. Biophys. Acta | 1967 | 143 | 435 |
| 84 | E. Bayer, A. Röder | Chelate Chemistry. | *Electron and energy transfer in biological systems*, (Eds.T. E. King, Klingenberg), Marcel Dekker, New York | 1967 | | |
| 85 | E. Bayer | Das Wechselspiel der Blütenfarben. | Palette | 1967 | 26 | 22 |
| 86 | A. Röder, E. Bayer | Vergleichende ESR-Studien am eisenhaltigen Aktivzentrum von Pflanzenferredoxin und Xanthinoxidase. | Hoppe-Seylers' Z. Physiol. Chem. | 1967 | 348 | 1335 |
| 87 | E. Bayer, G. Jung, W. König | Massenspektrometrie von Cysteinpeptiden | Z. Naturforsch. | 1967 | 22b | 924 |
| 88 | H. J. Bielig, E. Bayer, H. D. Dell, G. Rohns, H. Möllinger, W. Rüdiger | Chemistry of Hemovanadin. | *Proteides of the Biological Fluids*, (Ed. H. Peeters), Elsevier, Amsterdam. | 1967 | | 197 |
| 89 | E. Bayer, E. Breitmaier | Umlagerung und Komplexbildung des Glyoxal-bis(2-merkaptoanils) und anderer Merkaptoanile. | Chem. Ber. | 1968 | 101 | 1579 |
| 90 | E. Bayer, E. Breitmaier, V. Schurig | $^1$H-Kernresonanz-Untersuchungen an Fünfring-Chelaten. | Chem. Ber. | 1968 | 101 | 1594 |
| 91 | E. Bayer, G. Jung, H. Hagenmaier | Untersuchungen zur Totalsynthese des Ferredoxins. I Synthese der Aminosäuresequenz von C. pasteurianum Ferredoxin. | Tetrahedron | 1968 | 24 | 4853 |
| 92 | E. Bayer, H. Hagenmaier | Solid phase synthesis of oxytocin. | Tetrahedron Lett. | 1968 | 17 | 2037 |
| 93 | E. Bayer, H. Hagenmaier, W. König, H. Pauschmann, W. Sautter | Möglichkeiten der Massenspektrometrie bei der Sequenzanalyse von Peptiden. | Z. Anal. Chem. | 1968 | 243 | 670 |
| 94 | W. Voelter, E. Bayer, R. Records, E. Brunnenberg, D. Djerassi | Untersuchungen mit optischer Rotationsdispersion. Molybdat-Pyranose-Komplexe. | Liebigs Ann. Chem. | 1968 | 718 | 238 |
| 95 | E. Bayer, E. Breitmaier | Bildungsweise und Reaktionen von 2-Aryl-2-aroyl-benzothiazolinen. | Chem. Ber. | 1969 | 102 | 728 |
| 96 | E. Bayer, H. Eckstein, H. Hagenmaier, Josef, G. Koch, P. Kraus, P. Schretzmann | Untersuchungen zur Struktur der Ferredoxine. | Eur. J. Biochem. | 1969 | 8 | 33 |
| 97 | E. Bayer, W. König | Sequence Analysis of Peptides by Chromatography and Mass Spectrometry. | J. Chromatogr. Sci. | 1969 | 7 | 95 |
| 98 | E. Bayer | Neuere Ergebnisse der Synthese am Festkörper. | Chemie für Labor und Betrieb | 1969 | 1969 | 193 |
| 99 | E. Bayer, H. A. O. Hill, A. Röder, R. J. P. Williams | The interaction between heme-iron and thiols. | J. Chem. Soc., Chem. Commun. | 1969 | 1969 | 109 |
| 100 | E. Bayer, P. Kraus | Paramagnetischer Molybdän(V)-Cystein-Komplex. | Z. Naturforsch. | 1969 | 24b | 776 |
| 101 | W. Voelter, E. Bayer, R. Records, E. Brunnenberg, C. Djerassi | Untersuchungen mit optischer Rotationsdispersion: Molybdat-Polyalcohol-Komplexe. | Chem. Ber. | 1969 | 102 | 1005 |
| 102 | E. Bayer, V. Schurig | Stickstoff-Fixierung und Reduktion zu Ammoniak mit metallorganischen Katalysatoren. | Chem. Ber. | 1969 | 102 | 3378 |
| 103 | W. Voelter, E. Bayer, Barth, E. Brunnenberg, C. Djerassi | α-Hydroxysäure-Molybdat-Komplexe. | Chem. Ber. | 1969 | 102 | 2003 |
| 104 | E. Bayer, P. Krauss, P. Schretzmann | Künstliche Nicht-Häm-Eisenproteide aus Ribonuclease und Serumalbumin. | Hoppe-Seyler's Z. Physiol. Chem. | 1969 | 350 | 994 |
| 105 | A. Röder, E. Bayer | Elektronenspinresonanz-Untersuchungen an Hämin-Mercaptan-Komplexen. | Eur. J. Biochem. | 1969 | 11 | 89 |
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Table 1. *(continued)*

| Entry | Authors | Title | Journal | Year | Volume | Page |
|---|---|---|---|---|---|---|
| 107 | Jung, W. Voelter, E. Breitmaier, E. Bayer | $^{19}$F-NMR-Untersuchungen an trifluoracetylierten Polyolen. | Tetrahedron Lett. | 1969 | 43 | 3785 |
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Table 1. *(continued)*

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