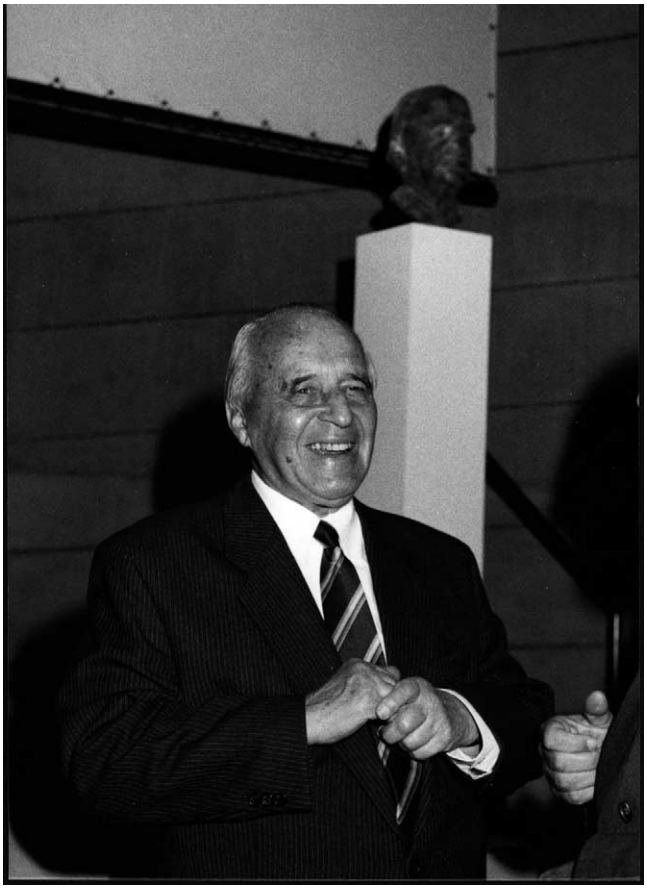
Available online at www.sciencedirect.com
SCIENCE DIRECT®
Journal of Organometallic Chemistry 684 (2003) 1–5
Journal of Organometallic Chemistry
www.elsevier.com/locate/jorganchem

Mediator between chemical worlds, aesthete of sciences, and man of Bavaria: Ernst Otto Fischer☆

Wolfgang A. Herrmann [a,b,*]

[a] Anorganisch-Chemisches Institut, Technische Universität München, Lichtenbergstrasse 4, Garching 85747, Germany
[b] President of Technische Universität München, Arcisstrasse 21, München 80333, Germany

Received 6 July 2003



Impulsive and contemplative man of the world and man of his home town, scientist and aesthete: it is just these opposites that make Munich's chemistry Nobel Prize winner Ernst Otto Fischer so interesting. Born in Munich 85 years ago and resident there ever since ('You

☆ Ernst Otto Fischer's successor in the chair for Inorganic Chemistry (since 1985).

* Tel.: +49-89-289-13080; fax: +49-89-289-13473.
E-mail address: lit@arthur.anorg.chemie.tu-muenchen.de (W.A. Herrmann).

0022-328X/03/$ - see front matter
doi:10.1016/S0022-328X(03)00715-0

stay here — immediately!' '*Du bleibst hier, und zwar sofort!'* Karl Valentin), the political catastrophes of the first half of the 20th century prompted the young Fischer to seek a Benedictine '*stabilitas loci*'. While on leave from his war service he was fascinated by the lectures of the inorganic chemist Walter Hieber at the technical university of Munich. His later academic advisor held such gripping lectures that the scholar of the humanistic Theresien Grammar School turned his attention to chemistry instead of the originally planned history of art.

Walter Hieber (1895–1976) had then just opened up the field of carbon monoxide complexes of metals. This not only served as the foundation for the later molecular catalysis chemistry for industrial use but also induced in the young student Fischer the dream — that ripened to a Nobel Prize — to combine metals with hydrocarbon fragments and with the new constructions to uncover the unexpected range of reactivity of the metals. To bridge the fields of inorganic and organic chemistry turned out to be the objective of Fischer's chemical works. We would not today be so involved with energy- and resources-sparing catalytic processes — in today's language 'green chemistry' — if Ernst Otto Fischer in Munich and his scientific rival Geoffrey Wilkinson in London had not paved the way with their basic research.

Basic research! Fischer paid no attention to the practical exploitation of his fabulous results. He was driven by curiosity and the ability to be amazed. From this he harvested the capacity for enthusiasm for us members of the younger generation who, in his opinion, should neither smoke nor get married. That the bachelor should discover the pleasures of partnership with Traudl Haas only after his retirement was something that the young, energetic professor of that time would hardly have believed. Chemistry was his life, his students his family. The top scientist demanded top results in exchange for the hard currency of his trust. This made a lasting impression on the young students.

In lectures also not just facts: Ernst Otto Fischer developed his subject chemistry like a work of art. Who as student could not understand why he placed Adalbert Stifter's 'Nachsommer' in the middle of an inorganic chemistry lecture might perhaps have understood later. To demonstrate principles on the basis of concrete and abstract, to emphasize continuity — these were the aims of the academic teacher: that science, literature and the arts are not contradictions. He wanted chemistry to be understood as a part of civilization.

But it was also loud in his lectures — because the experiments worked. This further supported the concept that our subject chemistry requires both intellectual handicraft as well as abstract thinking ('*Ja, es riecht nicht alles gut, was kracht.' — Yes, not everything that explodes smells good.* Karl Valentin).

When necessary Fischer also intervened in political affairs. In the year 1968, when the student revolutions offended even his liberal spirit, he came to a metal hydride lecture armed with Hitler's 'Mein Kampf' and Mao's Red Book — for exorcism with literature references. The large blackboard had to be cleaned twice in this hour...

Fischer is an offspring of both Munich universities. He laid the foundations for success at the 'TU' and as supernumerary university lecturer became famous overnight with the discovery of dibenzenechromium (1955). Soon after he became private professor at the university (1957), attracted enthusiastic students and brought international experts into his laboratories. Finally, at his *alma mater* the TU he took over the chair of his predecessor Hieber (1964–1984). During this period his institute developed to one of the finest international addresses.

Together with all his creative powers Fischer's great international success was also a masterpiece of management. He recognized in good time that the modern instrumental techniques (vibrational spectroscopy, mass and nuclear magnetic resonance spectrometry) would revolutionize molecular chemistry. He mastered this revolution by sending his best young scientists to specialists all over the world to learn all about the newest methods. On their return to Munich, the thus acquired knowledge was collected together and developed further. With applications in the new discipline of organometallic chemistry — which had its beginnings in Fischer's group in Munich — he placed one noteworthy result after the other in the scientific journals. Previously unknown or unsuspected bonding situations between carbon and metals (double and triple bonds, aromatic and olefinic systems) were demonstrated in masterly experiments and described with scientific precision. On the occasion of the Nobel Prize he thanked his former colleagues for the 'mutual adventure of research' and ungrudgingly attributed it to the performance of his co-workers. In contrast to others he had never speculated about a Nobel Prize. Thus, the child-like joy about it and the laureate remained modest. Today he lives happily in Solln and is often away on trips.

Ambitious young chemists emerged from Fischer's ivory tower who wanted to exploit their knowledge in the growing industry of the period of a blooming economy: Walter Hafner and Reinhard Jira should be mentioned here. In the Munich 'Consortium for the Electrochemical Industry' they discovered a catalytic process to produce the industrial chemical acetaldehyde from the feedstock ethylene (1957–1959). This genial step was a milestone in the history of chemistry and gave the young field of organometallic chemistry impulses from the user side. Today the subject is firmly anchored

in many industrial and academic laboratories and appears in the teaching plans of all universities.

Ernst Otto Fischer shared the Nobel Prize with Geoffrey Wilkinson (1921–1996). This was a keen scientific competition that drove the two similarly aged chemists to the highest achievements. The Englishman Wilkinson was intellectually especially outstanding but Fischer was more stable, consequent, active and impulsive. Fischer appreciated that 'in the night all things are bigger and more awesome than by day and become smaller when they can be recognized clearly' (Ludwig Thoma, 'Wittiber'). This gave him composure in the scientific competition. The Nobel Prize honoured in good time — Fischer was then 55 — the original development of classes of compounds that are characterized by metal–carbon bonds.

As an educated humanist Fischer explored the practical and methodologically difficult chemistry of organometallic compounds. His strength was the recognition of the red line and all its relationships. As pioneer of organometallic chemistry he influenced an era. A great man of Bavaria with whom Munich shines as the capital of German Science.

On November 10, 2003, Professor Ernst Otto Fischer will celebrate his 85th birthday. He led his institute — the Inorganic Chemistry Laboratory of our TU — to worldwide fame as an international centre for organometallic chemistry. The society of international chemists and the Munich chemical society will hold a public celebration in honour of Prof. Fischer. Exactly 30 years ago, together with Geoffrey Wilkinson (Imperial College London), Ernst Otto Fischer was awarded the Nobel Prize for chemistry for his pioneering and trend-setting work on the so-called sandwich organometallic compounds.

Ernst Otto Fischer was born in Solln on November 10, 1918 as the son of the Professor of Physics of the former Technical College Munich and later Director of the Bavarian Administrative Office for Weights and Measures, Karl Tobias Fischer. He attended the Theresien Grammar School, which he left with his school-leaving certificate in 1937. Labour service and basic military training directly followed by drafting for war service 1939–1944 as an officer at first prevented the start of his planned studies of science; these were then finally started during a short leave in the winter term 1941–1942. In contrast to his original intentions he chose to read chemistry at the Technical College Munich. However, his education was repeatedly interrupted by war injuries and the post-war period. Only after his release as a prisoner of war and the reopening of the technical college was he able to continue with difficulty his studies and complete them in 1949 with honours. Three-years later he finished his Ph.D. work under Professor Walter Hieber [1] with an experimental thesis on a topic in the field of metal carbonyl chemistry. In 1954 he achieved his Habilitation with a work entitled 'Metal Compounds of Cyclopentadiene and Indene'. Just 1 year later he was appointed as a supernumerary university lecturer at the Technical College, Munich. With the elucidation of the structure of ferrocene (1952) [2] on the basis of X-ray diffraction data in cooperation with Wolfgang Pfab (later BASF AG) and the synthesis of dibenzenechromium (1955) in collaboration with Walter Hafner [3], Ernst Otto Fischer advanced within a few years to one of the internationally recognized chemists. As early as 1957 he received an associate professorship at Munich University. After rejecting an appointment to the chair in Jena made famous by Franz Hein he was named as private professor at Munich University. He also rejected a call to the University of Marburg. The offer to be successor of his mentor Walter Hieber brought him back to the staff of our TU at the age of 46 years. He retained this chair as fifth successor of Emil Erlenmeyer until his retirement in 1984, when I had the honor to become his successor.

1. Ernst Otto Fischer the scientist

Ernst Otto Fischer came late and moreover, only by chance to study natural science. It was Walter Hieber (1895–1976) with his impressive, precise lectures who made such an impression on the young scholar Fischer. At that time Hieber was already a successful and recognized pioneer of the so-called metal carbonyl chemistry. The so-called basic reaction of metal carbonyl according to the equation

$$\mathrm{Fe(CO)_5 + OH^- \rightarrow \{[(CO)_4FeC(=O)OH]^-\} \rightarrow [(CO)_4FeH]^- + CO_2} \quad (1)$$

bears his name, but he also demonstrated with many other examples that the metal carbonyls are typical and manifold reactive compounds of the transition metals in low valent, i.e., in low oxidation states. Important discoveries by other researchers — e.g., the hydroformylation reaction found by Otto Roelen at the Ruhrchemie in Oberhausen (1938) in which metal carbonyl derivatives participate as catalytic key species provided further decisive impulses in the same direction as his research.

Characteristically, Fischer obtained his Ph.D. under Hieber with a thesis on, among others, the classical nickel tetracarbonyl. With this he was already well acquainted with the chemistry of the metal–carbon bond — by definition a prerequisite of organometallic chemistry — when he read in the journal Nature about the discovery of dicyclopentadienyliron with the formula $C_{10}H_{10}Fe$ by Kealy and Pauson — the com-

pound soon became known by the trivial name ferrocene. Fischer's doubts about the originally suggested structure of ferrocene with two its iron–carbon σ-single bonds prompted him, initially with the student Reinhard Jira (now retired from Wacker-Chemie GmbH, Burghausen), to carry out carbon oxide pressure experiments; the lack of formation of iron pentacarbonyl, $Fe(CO)_5$, led to the concept of coordinative saturation of iron and thus to the double cone structure in which the unusually high stability and the diamagnetism of the compound made the assumption of the penetrating complex feasible.

X-ray diffraction work together with Pfab added support to this idea and, practically simultaneously, Wilkinson and Woodward (then at Harvard University) correspondingly proposed the same sandwich structure. In an in part bitter but always fair competition with Wilkinson (later in London) novel organometallic compounds were prepared, starting with iron and then encompassing practically all transition metals; as well attempts were also made to extend the principle to some main group elements such as beryllium, tin and bismuth.

A first milestone was set by Ernst Otto Fischer together with Walter Hafner (now retired from the Consortium for the Electrochemical Industry GmbH, Munich) in 1955 with the preparation of dibenzenechromium $(\eta^6\text{-}C_6H_6)_2Cr$. This molecule is isoelectronic with ferrocene and, like the latter, has a double cone (sandwich) structure. The volatile, oxidisable, sublimable dibenzenechromium has a surprising thermal stability — decomposition cannot be observed up to about 300 °C; it also represents the first confirmed example of the metal compound of the neutral molecule benzene. What was then new is today spread over a large part of the periodic table and is part of the basic knowledge of our chemistry students. In the past 50 years the chemistry of π-aromatic complexes has been thoroughly investigated in many laboratories both from the aspects of pure scientific curiosity as well as the practical applications of such systems in reactions of organic synthesis and in catalysis.

The pioneering works of Ernst Otto Fischer and his research group in the early 1950's in the field of preparative organometallic chemistry attained even greater international significance because industrially important discoveries were made just in the same development phase of this new field of chemical research. Hence, Karl Ziegler and co-workers at the Max Planck Institute for Carbon Research in Mülheim/Ruhr noticed the ability of so-called organometallic mixed catalysts, consisting preferentially of aluminium and titanium components, to induce the low-pressure polymerisation of ethylene. The products are polymeric materials (current production capacity ca. 10 000 000 jato worldwide) that introduced the plastics era on account of their particular advantages in properties and processing. At the beginning of the 1960's research workers at Wacker-Chemie, including Fischer's students Hafner and Jira, developed the partial oxidation of ethylene to acetaldehyde under homogeneous catalysis according to the equation

$$C_2H_4 + PdCl_2 + H_2O \rightarrow CH_3C(=O)H + 2\ HCl + Pd \quad (2)$$

in which catalyst regeneration by copper chloride-catalysed air oxidation helped the actually organometallic process to reach technical maturity. At about the same time the particular catalytic ability of some rhodium complexes for industrially important C–C bond forming reactions was observed in the USA. Although these commercially applicable discoveries promoted an extraordinary international heyday of the young organometallic chemistry, it was Fischer's group in Munich who, in tenacious research work undaunted by any setbacks in great continuity, discovered ever new classes of compounds.

From the more than 200 experimental papers on aromatic complexes of the transition metals, the so-called carbene complexes emerged in 1964 in which ligands composed of divalent carbon were bound to lower-valent transition metals. While the utility of this unexpectedly stable class of compounds could not be accurately assessed at that time, today they continue to be of major relevance for the mechanisms of industrial reactions such as, for example, olefin metathesis, olefin cyclopropanation, and in principle, even the syntheses of some vitamins. When praising Fischer's works, the discovery in 1964 in collaboration with Alfred Maasböl of the first metal–carbene complex $(CO)_5W[=C(OC_6H_5)CH_3]$ must be considered as a second highlight [4]. Then with the use of the modern methods of structural elucidation already available in Fischer's laboratories a further decade later the Munich group achieved its third convincing scientific highlight under the decisive participation of the postgraduate student Gerhard Kreis, namely the synthesis of the first carbyne complex [5], $(CO)_4IW[\equiv CC_6H_5]$ — a compound with a metal–carbon triple bond.

2. Ernst Otto Fischer the academic teacher

One of the reasons for his success was Ernst Otto Fischer's ability to inspire his young co-workers in that he shared successes and failures with them equally. This honour has been earned by my co-workers — with these words Fischer commented on the award of the Nobel Prize for Chemistry (together with Geoffrey Wilkinson) exactly 30 years ago. There stood an academic teacher before us ungrudgingly and honour-

ably sharing the fame he did not chase after! His family were the altogether more than 200 undergraduate and graduate students and post-doctoral fellows from Germany and abroad. The spirit created from this understanding gave wings to the scientific engagement from which the scientific results emerged. Fischer's laboratory showed everyone what chemistry should be: intellectual handicraft. This was clear to students in their first term for whom the institute director had a special solicitude.

Even a telegram-style characterization of the academic teacher Fischer would remain incomplete without mention of his joy about the successful synthesis of a new substance or the achievement a correct elemental analysis result. Accordingly support for the next generation of qualified scientists was always a special concern of the Nobel Prize winner. Twelve of his former students have been appointed to chairs in universities: H.P. Fritz, Munich; H. Werner, Würzburg; R.D. Fischer, Hamburg, C. Kreiter, Kaiserslautern; H. Brunner, Regensburg; G. Herberich, Aachen; M. Herberhold, Bayreuth; J. Müller, Berlin, G. Huttner, Heidelberg, H. Fischer, Konstanze; K.H. Dötz, Bonn and U. Schubert, Vienna.

He also attempted to help through time-consuming activities in important national and international organizations; these include the Deutsche Forschungsgemeinschaft (main committee and Senate), the Deutsche Akademische Austauschdienst, and the Kuratorium of the Deutsche Museum. His main intention was to safeguard the freedom for the unhindered development of scientific talent for the following generations of scientists. Even today the fearless and committed university tutor is influenced by his (many) worries about the future of the free, autonomous universities.

As educated humanist, Fischer categorically rejected throughout his life any patronization of university research in academic institutions by outside parties, but in the 1960's during the periods of unrest in the universities he also vehemently rebuked the politically polarizing students. The quality of education and research were his highest and sole motto which he together with others — in spite of all opposition — rescued from the storm of university politics.

In this respect also the numerous honours and awards were highly deserved: Academy Prize for Chemistry from the Academy for Science of Göttingen (1957), Alfred Stock Memorial Prize from the Society of German Chemists (1959), Member of the Mathematic-Natural Science Class of the Bavarian Academy of Sciences (1964), Member of the German Academy or Researchers Leopoldina zu Halle (1969), Honorary Doctor Degrees from the universities of Munich and Strathclyde (Glasgow, UK, 1975), Memberships of the Austrian Academy of Sciences, the Italian Accademia Nationale dei Lincei, American Chemical Society Centennial Foreign Fellow (1976), Honorary Doctor Degrees from the Universities of Erlangen-Nürnberg/1977) and Veszprem (1983), Corresponding Member of the American Academy of Arts and Sciences/1977), Honorary Fellow of the Royal Society of Chemistry (UK) (1979), Honorary Member of the German Chemical Society (1985) and Corresponding Member of the Rheno-Westphalian Academy of Science (1987).

Ernst Otto Fischer is one of the outstanding personalities in chemistry in the second half of the 20th century because he decisively influenced the renaissance of inorganic chemical research at the boundary to organic chemistry. His decade-long activity on the editorial board of the journal 'Journal of Organometallic Chemistry' which appears weekly and is the most cited journal in the field of organometallic chemistry also deserves mention. Here also Fischer made a responsible contribution from the very first days back in 1964. From the view point of the history of science he is even today to be recognized as the person who from a few at first individual and unexpected observations helped to develop the new subject of organometallic chemistry into a convincing field with many useful reactions that is now accepted without hesitation by the chemical community. There are hundreds, thousands of well characterized compounds which Fischer and with him our TU has reported in the literature during almost 40 years of his adventure science.

Building up from the metal carbonyl chemistry learnt from his teacher and predecessor in Munich, Walter Hieber, Fischer broke out into new dimensions in the chemistry of metal–carbon bonds. Together with others a rich harvest had been brought in reaching from a deeper understanding of the chemical bond in general to preparatively and industrially useful organometallic systems in particular. The Technical University of Munich has accompanied his successful life's work with support and has been able to provide the necessary fruitful environment. We are proud of our faculty member Ernst Otto Fischer.

References

[1] (a) E.O. Fischer, Chem. Ber. 112 (1988) XXI;
(b) W.A. Herrmann, Chem. Unserer Zeit 22 (1988) 113.
[2] E.O. Fischer, W. Pfab, Z. Naturforsch. B 7 (1952) 377.
[3] E.O. Fischer, W. Hafner, Z. Naturforsch. B 10 (1955) 655.
[4] (a) E.O. Fischer, A. Maasböl, Angew. Chem. 76 (1964) 645;
(b) E.O. Fischer, Angew. Chem. 86 (1974) 651 (Nobel Lecture).
[5] E.O. Fischer, G. Kreis, C.G. Kreiter, J. Müller, G. Huttner, H. Lorenz, Angew. Chem. 85 (1973) 618.