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Homage to *Werner Stumm*, *Kurt Grob*, and *Jürg Hoigné*

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Much of the success of 'Chemistry at EAWAG' as is described in this issue of CHIMIA is based on the pioneering work of *Werner Stumm*, the late *Kurt Grob*, and *Jürg Hoigné*. These three scientists were so paramount for the development of chemistry at EAWAG that we feel it to be highly appropriate to reflect on their scientific contributions in this short article.

Werner Stumm – Pioneer of Aquatic Chemistry

Werner Stumm was director of EAWAG, head of its chemistry department, and professor at ETH from 1970 to 1992. At EAWAG, he stimulated the development of environmental and analytical chemistry, and he built up aquatic and surface chemistry.

Werner Stumm was guided by the idea that chemical processes need to be understood at the atomic and molecular level in order to gain insights into global geochemical cycles, the anthropogenic perturbations, and the fate of pollutants. His own research, that he had started during his years at Harvard University, was fundamental for the discipline of aquatic chemistry. *Werner Stumm* applied the theoretical basis of solution and coordination chemistry to the processes in natural waters and in water technology. His book 'Aquatic Chemistry', co-authored with *J.J. Morgan*, that first appeared 1970 and more recently in its 3rd edition 1996, is the classic textbook on this subject [1].

The most important part of his research activities focused on the processes at the interfaces between the solid phase and solution and on the application of these reactions (adsorption, dissolution, redox reactions) to processes in natural waters and in water technology (*e.g.*, weathering, dissolution, and nucleation of minerals). The kowledge of these processes is a prerequisite for the understanding of the geochemical cycles, the influence of acid deposition on ecosystems, and the environmental fate of pollutants on local, regional, and global scales.

The surface complexation model [2][3], that has been developed by *Werner Stumm* and *Paul Schindler* (University of Berne), postulates a chemical binding between adsorbed cations and ligands and oxide surfaces. These mechanisms, which were first proposed on the basis of chemical equilibria, have later been confirmed by spectroscopic methods. This model provides a basis for the understanding of dissolution reactions of oxides as well as for the catalysis of redox reactions at surfaces, and has largely influenced the aquatic surface-chemistry field [4].

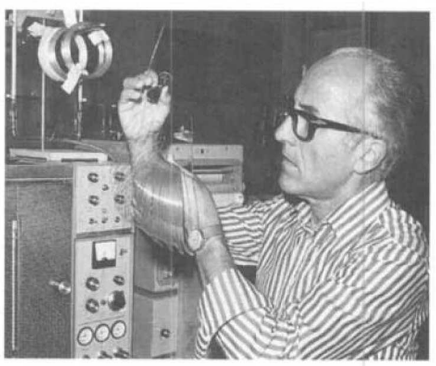
Under *Werner Stumm*'s guidance, 28 students completed their Ph. D. theses at EAWAG and enjoyed a stimulating scientific environment in his research group. Many of these former students and postdoctoral collaborators are now active in the environmental field, at universities, at research institutes, in environmental consulting, in the industry, and in regulatory agencies.

Werner Stumm recognized early the necessity of an interdisciplinary approach in environmental science. He has encouraged collaboration between various disciplines as well as studies on the interactions beween water, soil, and air. He has always considered the importance of the global environmental issues, in addition to the local ones.

His pioneering activities at EAWAG are a cornerstone of modern environmental chemistry and have been initiating research on many of the topics that are presented in this issue.

Kurt Grob – Father of High-Resolution Gas Chromatography with Glass Capillaries

Kurt Grob started to work at EAWAG in 1974 while he was still a chemistry teacher at the Kantonsschule Rämibühl in Zürich. His major research activities had originally been in connection with the analysis of tobacco smoke. For that purpose, he developed high-resolution gas chromatography with glass capillaries. In the early 1970s, he began to apply his microtechniques to environmental samples. He started out by studying the pollution of Zürich's air and then he developed enrichment techniques for the determination of water pollutants. He carried out these developments with their practical application in mind, as is reflected by the fact that some of his first environmental publications appeared in the *Neue Zürcher Zeitung* [5].



Kurt Grob worked mostly in a small team with his wife *Gertrud Grob*, sometimes supported by other members of the family, such as his son *Konrad Grob* and his son-in-law *Joachim Schmid* who both became very reputable analytical chemists themselves. The specialty and a major advantage of *Kurt Grob* were that during his whole career he remained an experimental researcher doing a large part of his experiments himself. That approach enabled him to achieve insights into the functioning principles of gas-chromatographic procedures including all the often very important details.

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The numerous developments of *Kurt Grob* in the field of high-resolution gas chromatography [6] were directly transferred to the other EAWAG groups which could greatly profit from this direct support. Besides the generally applicable high-resolution gas chromatography with glass capillaries, he developed enrichment procedures for organic micropollutants in aqueous samples. These methods were subsequently employed by many analytical groups in Switzerland and in other countries. The closed-loop gaseous stripping technique, *e.g.*, found its way into the Swiss standard methods for water analyses. An extraordinarily elegant development was the direct aqueous injection method for polyhalogenated volatile hydrocarbons using a bonded-phase glass capillary and electron capture detection.

Kurt Grob received two honorary doctoral degrees: one from the University of Berne for his teaching activities and the second from ETH Zürich for his research. In 1983, ETH Zürich also awarded him the title of a Professor for Analytical Chemistry, in recognition of his scientific and educational contributions through his 'hands-on' GC courses.

The help of *Kurt Grob* was an invaluable asset for all EAWAG researchers who were using high-resolution gas chromatography for the determination of organic micropollutants. At the end of his career, *Kurt Grob* finally carried out what he had refused to do for many years: He wrote a praxis-oriented textbook on HRGC [7]. Today the invention of fused silica GC capillaries has surpassed glass-capillary technology in many laboratories. However, for many difficult applications, HRGC work at EAWAG is still based on glass capillaries self-made according to *Grob*'s procedures.

Jürg Hoigné – Master of Aquatic Kinetics

Jürg Hoigné joined EAWAG in 1973 after he had spent the first part of his career in radiation chemistry. With his strong background in physical chemistry and particularly in chemical kinetics, he started a research group on oxidation kinetics in aquatic chemistry. His first activities were centered on the application of ozone in water and wastewater treatment. In 1975, he published a breakthrough article in *Science* [8] describing the role of hydroxyl radicals as oxidizing intermediates in aqueous solutions. This was the start of a long series of publications which he co-authored with his long-time technical assistant *Heinz Bader*. A comprehensive treatment of reactions rates of ozone with organic and inorganic compounds [9] can be mentioned as a typical result of the work by *Bader* and *Hoigné*.

Hoigné and *Bader* developed many experimental procedures for aqueous ozone chemistry including an analytical method for the determination of ozone which became the basis for a current standard method. Subsequently, they focused on the kinetic aspects of chlorine-dioxide reactions and photochemistry of aqueous ozone.

Jürg Hoigné was very actively involved in teaching aquatic chemistry of drinking water and wastewater treatment for engineering students as well as environmental chemistry for chemistry majors. In 1977, he received the title of Professor for Environmental Chemistry by the Department of Chemistry of ETH Zürich. From 1986 to 1995 he was head of the Institute for Aquatic Sciences and Water Pollution Control, the institute of ETH Zürich located at EAWAG.

With his in-depth knowledge of reaction kinetics *Jürg Hoigné* also performed pioneering work on photochemical reactions in surface water including the role of singlet oxygen, superoxide ions, peroxyl radicals, solvated electrons, and hydoxyl radicals [10]. In a very convincing way, *Jürg Hoigné* could show how the results of surface-water studies could be transferred with relative ease to the processes occurring in atmospheric water in clouds or fog [11]. In cloud-water chemistry, the role of copper, the redox cycling of iron, and the oxidation of sulfur species were emphasized.

Another focus was the modeling of photochemical reactions and formation of disinfection by-products possibly being formed in water and wastewater treatment, *e.g.*, bromate formation during ozonation. For many years, the group of oxidation kinetics consisted of graduate students, postdoctoral fellows, and permanent EAWAG employees. For all of them, *Jürg Hoigné* was a very inspiring group leader and a highly motivating mentor.

In many of his research projects, *Jürg Hoigné* aimed at achieving conclusions which could also be used for teaching purposes. By doing this, he was able to produce research results of very broad value for various fields of application. He always stressed the importance of kinetics in chemical processes and influenced many projects at EAWAG in such a way that he could be termed as the kinetic conscience of chemistry at EAWAG.

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