DOI: 10.1002/anie.201406956

Catalytic Processes that Changed the World: 100 Years Max-Planck-Institut für Kohlenforschung

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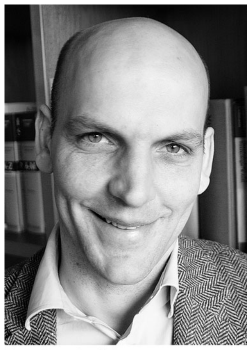

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This issue of *Angewandte Chemie* is dedicated to the Max-Planck-Institut (MPI) für Kohlenforschung on the occasion of its centennial. A good reason to celebrate, as catalytic processes that have changed the world have been developed at this institution in Mülheim.

Such an anniversary is also a good opportunity to take a look back at the exciting history of this Institute and to investigate the secrets of its success. I would like to say one thing up front: My conclusions may be debatable. In fact, they lead to the realization that the success of the MPI für Kohlenforschung does not only originate from its admittedly generous funding or its scientific concepts, but rather from the people who work there and the values that they have shared for a century: freedom and trust.

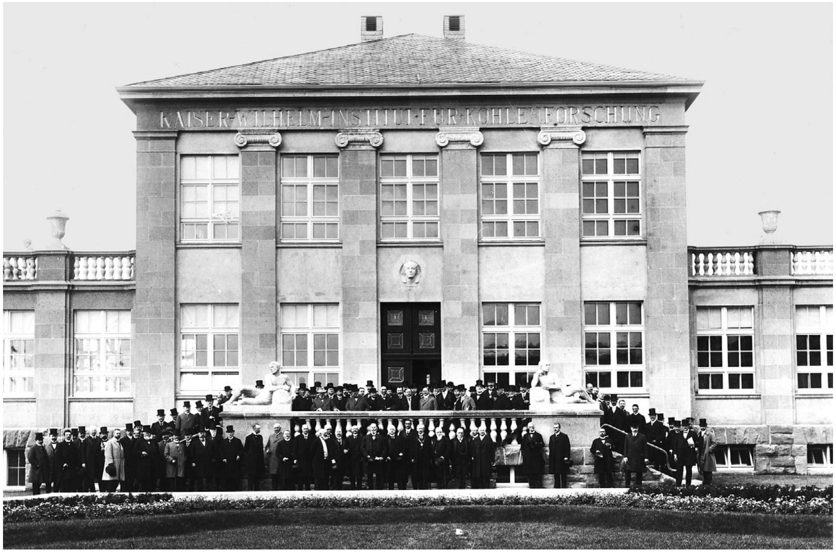

Figure 1. The Institute in the early days.

In the early days, this Institute, which was opened in 1914 and situated close to coal mines and coking plants, actually focused on coal research, more precisely on the scientific studies on the usage of coal. Fundamental basic research was intended from the beginning, as witnessed by the artwork, which may nowadays seem romanticized, on the historic building of the Institute: The main entrance of the Institute is ornamented with the head of a sphinx, intended to symbolize that the riddles of nature are being investigated here. At heart, nothing has changed in this sense up to now.

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The first spectacular chemical finding of the Institute was made quite soon after its opening, with the discovery of the Fischer–Tropsch reaction in 1925. Somewhat simplified, this reaction, which was discovered by the founding Director Franz Fischer and his co-worker Hans Tropsch, enables the transformation of coal and water into gasoline. As described elsewhere in this issue, synthesis gas is first generated from coal and water ($C + H_2O \rightarrow H_2 + CO$) and the resulting gas mixture then reacts to form alkanes in the presence of iron or cobalt catalysts. The Fischer–Tropsch process is still used on a large scale today. For example in Qatar, 50 billion barrels of gasoline were produced from natural gas in 2012.

Figure 2. The sphinx head above the main entrance.

For me personally, the Fischer–Tropsch reaction is particularly fascinating, as it represents a truly universal reaction. On one hand, nearly all carbon sources can be used to generate synthesis gas. On the other hand, the process, as an alkane synthesis, represents an entry into the entire cosmos of organic chemistry. Who knows, maybe one day the process will

Figure 3. The Institute today.

enable industrial-scale chemistry on the basis of renewable resources such as plant waste or wood. As you can see, this almost 100-year-old process from Mülheim is, even from today's perspective, much more than a historical footnote. It continues to be of tremendous economic and scientific importance.

Despite this impressive example of "planned research", the Institute has always focused on basic research. Fischer's successor as Director of the Institute, Karl Ziegler, even explicitly claimed the right for him to *not* conduct research on coal. He was interested in the basic principles of organometallic chemistry, which at that time meant largely unexplored, dangerous compounds that spontaneously ignite upon contact with air and react explosively with water. Quite exotic, you may say, but this perfectly demonstrates the degree of trust that the Kaiser-Wilhelm-Gesellschaft bestowed on its Directors at that time, and the freedom they enjoyed.

Ziegler was particularly intrigued by organo-alkali-metal compounds such as 2-phenylisopropyl potassium. At the outset, he was most likely not thinking about the production of polymers. This changed through an unexpected side reaction (described again in the Essay by Manfred Reetz in this issue). Ziegler quickly recognized the potential of his discovery, namely the catalytic properties of organometallic compounds in the polymerization of olefins, and thus also demonstrated good business acumen. For the chemical industry, polyolefins such as polyethylene and polypropylene are important products, of which nowadays more than a hundred million tons are produced each year worldwide, amounting to several hundred billion Euros in revenue. Plastic bags, toys, tubing, airplane parts, or computers: A world without polymers is almost unthinkable today. Not only this, polymers continue to be an exciting area of scientific research.

The success story of Karl Ziegler is at the same time a wonderful example of the success of the Harnack principle of the Max-Planck-Gesellschaft (MPG; Max Planck Society). This wonderfully simple idea basically encompasses recruiting outstanding scientists, and giving them as much freedom as possible for their research. Over the last 100 years, the MPI für Kohlenforschung has impressively demonstrated that this principle not only provides a highly attractive working environment for excellent scientists, but also that it can lead to great scientific success.

In my opinion, another pillar of success for the Institute, besides the Harnack principle, is that of trust-based research funding. Of course, there is monitoring in the MPG as well, which is secured through an Advisory Board featuring independent, accomplished scientists. But this control is exercised a posteriori and is not based on proposals. This is a fine but decisive difference, and I am surprised again and again that this successful model of the MPG is not copied much more often in Germany as well as other countries.

Besides the Ziegler catalysts and the Fischer–Tropsch process described above, another noteworthy contribution from the MPI für Kohlenforschung is the decaffeination of coffee by Kurt Zosel. It represents an environmentally friendly process, which utilizes supercritical carbon dioxide to extract the caffeine with high selectivity from the still green coffee beans. I also like to remember Günther Wilke's discovery of the nickel-catalyzed trimerization of butadiene, which is used on large scale today. The product of this reaction, cyclododecatriene, serves as starting material for the production of polyamides, which can be used, for example, in car interiors and also in football boot cleats, such as in the 1974 World Cup. Permanence and long-term perspectives have always been emphasized at the MPI für Kohlenforschung. For example, organometallic catalysis has a 70-year tradition here. Despite this long history, research at the Institute has repeatedly renewed itself completely. Consider for example the research on biocatalysis, which was initiated by Manfred Reetz in the 1990s. His "directed evolution" of enzymes has become a standard technique today and the triumph of biocatalytic processes with evolved enzymes for the production of pharmaceuticals continues.

Today, our Institute with its five departments aspires to cover all aspects of catalysis research, including homogeneous, heterogeneous, organometallic, biological, organic, theoretical, and technical catalysis. Despite this, we have opted against renaming the Institute as the "Max Planck Institute for Catalysis". We are not willing to sacrifice the brand "Kohlenforschung", which has been established for over a century—although only one of nine Directors at this Institute has had so far conducted coal research in the strict sense.

When I, as Managing Director of our Institute, look at the history of the Kohlenforschung today, I experience a certain pride, but above all, I feel humble and grateful. Humble, as the achievements of our predecessors, which were maybe judged as exotic by their contemporaries, from today's perspective are so incredibly impressive. Grateful, because my colleagues and I experience the same trust from the MPG that was already enjoyed by Franz Fischer, Karl Ziegler, and Günther Wilke, and because we enjoy the same scientific freedom.

In this special issue of *Angewandte Chemie*, which is indeed very special for us, you as a reader should get an impression of what, in our opinion, constitutes the research in and around the MPI für Kohlenforschung. You will notice the diversity of the research topics that are covered by researchers at the Institute.

And yet, with all the different facets that our scientists have brought to enrich this Institute in the past century, one common theme remains: We are all devoted to basic research.