Liquid fuels from coal – how a key process for fuel production was invented and patented in Mülheim in 1925

In 1925, Fischer-Tropsch synthesis was invented by chemists Franz Fischer (1877–1947) and Hans Tropsch (1889–1935) at the Kaiser-Wilhelm-Institut (KWI) für Kohlenforschung in Mülheim an der Ruhr. Even today, it is still one of the most important reactions in the field of heterogeneous catalysis. Their invention was a research project that lasted for years. The motivation behind it can be explained by the historical situation in the German Reich.

Franz Fischer, 1940.

At the beginning of the 20th century, the energy requirements in the industrialized countries had changed. The onset of motorization increased the demand for liquid fuels, which were needed to power cars and later aircraft. Although the German Reich had large coal reserves, it had hardly any oil or natural gas deposits of its own. In order to avoid dependence on imports (e.g. from the US), the aim of the policy was to develop a chemical process for converting hard coal into liquid fuels and lubricants.

Processes for “coal liquefaction” were already known. In 1869, the French chemist Marcelin Berthelot (1827–1907) had found a way to hydrogenate coal. However, because of the high costs, his method had no potential for industrial use. A method of direct hydrogenation developed by Friedrich Bergius (1884–1949) seemed more promising. The Bergius-Pier process (filed for patent in 1913) is a two-stage reaction that makes it possible for carbonaceous substances to be broken down into their constituent parts using heat and hydrogen and then refined into liquid fuel. However, difficulties arose in the large-scale implementation. Only after the First World War were these sufficiently resolved.

Research at the Kaiser-Wilhelm-Institut in Mülheim

Because only a small amount of research had been done on coal at the beginning of the 20th century, the Kaiser-Wilhelm-Institut (KWI) für Kohlenforschung was founded in Mülheim an der Ruhr in 1912. In 1914, the Institute started its research activities as a union of policy, science, and industry. Franz Fischer, who had previously been Professor of Electrochemistry at the TH Charlottenburg, became the first Director of the Institute.

Hans Tropsch (centre) in the synthesis laboratory of the KWI, 1922.

When the supply of lubricants and fuels was exhausted during the First World War, research on the production of synthetic fuels based on the “Bergius process” began at the KWI. Together with chemist Hans Tropsch, Fischer developed a new way of liquefying coal. Pressure, temperature, and the catalysts used were systematically varied in numerous tests. In indirect hydrogenation, coal and hydrogen are first converted into a synthesis gas by strong heating. The gas then reacts with a metal catalyst and can thus be converted into a liquid fuel or lubricant.

1925: The patent application and the following industrial application

After many years of research, the process was finally registered for patent on 20 July 1925. In the following years, it was continuously optimized in order to allow for industrial application.

For this purpose, a test facility was set up on the Institute's premises. Experiments were conducted with various catalysts and synthesis gases. The researchers succeeded in producing a broad spectrum of liquid and gaseous hydrocarbons. These were used to generate gasoline and diesel as well as synthetic motor oil and chemical raw materials.

Franz Fischer at a Fischer-Tropsch plant, around 1934.

Pilot plant for the Fischer-Tropsch synthesis, 1930.

From an economic point of view, the procedure was not profitable during the Weimar Republic. However, this changed when the National Socialists came to power in January 1933. With the underlying goal of achieving raw material self-sufficiency, the regime subsidized the large-scale implementation of synthesis. As a result, the construction of Fischer-Tropsch plants was massively promoted. By 1941, there were nine plants with a production volume of 300,000 tonnes per year, which contributed to the production of lubricants and fuels during the Second World War.

The synthesis after the end of the Second World War and its significance today

Because of the increasing availability of crude oil at favourable prices, the economic basis for the Fischer-Tropsch process in Germany dwindled after the end of the war. However, interest in this synthesis remained in other countries. In the mid-1950s, the construction of Fischer-Tropsch plants began in countries like South Africa with its large coal deposits near the earth's surface. In the following decades, the process was further developed by expanding the raw materials that could be used. Nowadays, the Fischer-Tropsch process still plays an essential role in the large-scale production of synthetic fuel from coal and natural gas in various countries, including South Africa, Nigeria, and Qatar. This synthesis is also gaining increased attention for the conversion of biomass and industrial waste gases such as CO and CO_2 into bulk chemicals and fuels. In the Biomass-to-Liquids (BtL) process, a synthesis gas is produced under heat from biomass not suitable for food (straw, wood waste). This gas is then converted into hydrocarbons in the Fischer-Tropsch process and later into a biofuel using processes from petroleum refining. Researchers in the Department of Heterogeneous Catalysis at the MPI für Kohlenforschung are working on refining the synthesis methods and finding suitable catalysts for this process. One possible commercial use of the process is being considered. But there are many more connections to be explored along the way. Fischer-Tropsch synthesis is a good example of the relevance of basic research. A look into history shows how the discovery (patented 95 years ago in Mülheim, Germany) has been – and still is being used in many chemical processes around the world.

Contact:

Max-Planck-Institut für Kohlenforschung
Historical archive/Public relations
Telephone: +49 0208 306 1
Email: contact@mpi-muelheim.mpg.de
Photos: Max-Planck-Institut für Kohlenforschung/Historical archive