July 2021

Tackling thick air - protein building block helps bind atmospheric CO_2: Process from the Rostock LIKAT

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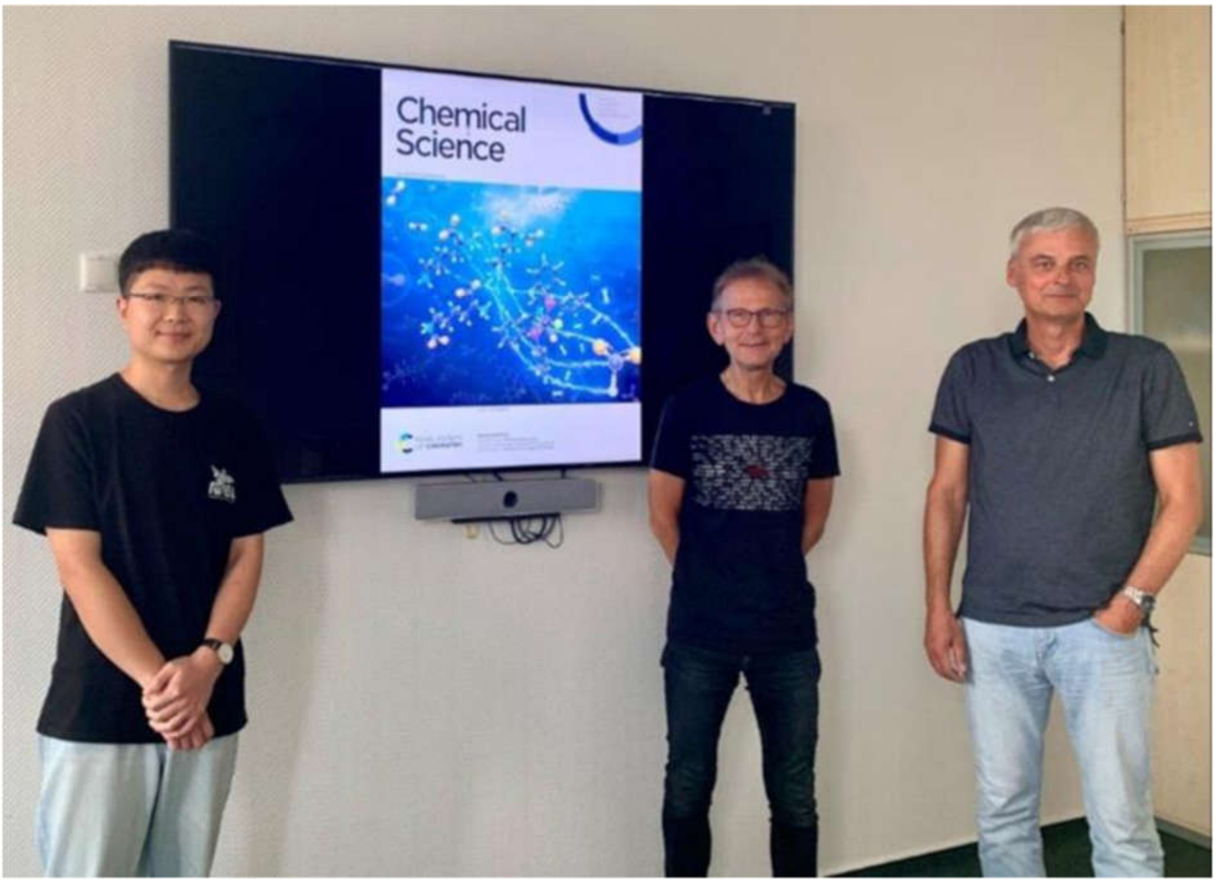
A new process from the Leibniz Institute for Catalysis in Rostock is able to produce formates, a basic chemical substance, directly from carbon dioxide in the air. In addition to the catalyst, the reaction requires only hydrogen and the amino acid L-lysine. This is one of 20 essential amino acids that make up proteins.

With this research result, chemistry is taking another step away from its traditional fossil raw material base - crude oil and natural gas - at least in the laboratory, towards sustainable processes that protect the climate and conserve resources. The paper was published in the renowned journal CHEMICAL SCIENCE.



The authors (from left to right): Duo Wei, LIKAT Director Matthias Beller and Henrik Junge

Formates are the salts of formic acid. They are suitable, for example, for pickling, impregnating, preserving and organic syntheses. Worldwide, 800,000 metric tons of them are produced annually. Until now, this has been done on the basis of carbon monoxide, because their synthesis, like the production of the vast majority of everyday things in the world, requires carbon. "In the future, the urgent question will be to find new carbon sources," says Dr. Henrik Junge, co-author of the publication in CHEMICAL SCIENCE, explaining the importance of the research topic. After all, in order to halt global warming, the world community is just learning to gradually abandon fossil raw materials and fuels.

Climate gas as a raw material

Experts have therefore been discussing CO_2 from the air as a raw material for some time. On the one hand, atmospheric carbon dioxide, with its increasing concentration of currently more than 400 ppm, is severely damaging the climate. On the other hand, this concentration is far too low for direct processing in chemical processes. And the processes currently used for enrichment are expensive and time-consuming.

So far, only the exhaust air from power plants and other industrial facilities that emit more concentrated CO_2 has been used in practice. There, so-called amine scrubbing retains the CO_2 so that it becomes available as a raw material. However, amines are toxic and their intense odor is particularly irritating in the vicinity of biogas plants. Moreover, as derivatives of ammonia, they are a product of petroleum-based chemistry, which is supposed to be replaced.

So the question is: Which environmentally compatible and less toxic substances are suitable for binding the carbon dioxide? For CHEMICAL SCIENCE authors Duo Wei, Henrik Junge and LIKAT Director Matthias Beller, amino acids were the obvious choice. Henrik Junge: "We know from the literature that amino acids can hold CO_2 in high concentration in aqueous solution."

Reaction partners from nature

The LIKAT chemists took as an example a protein called RuBisCO, it is the most abundant protein produced by photosynthesis. One component of it is the amino acid L-lysine, which in turn stabilizes CO_2 for further metabolism, in the form of carbon-containing salts: carbamantes and bicarbonates. They are all part of catalytic mechanisms in nature that increasingly serve as models for chemical reactions as well.

In fact, the trio of Wei, Junge and Beller were able to exploit this process. On the one hand, they demonstrated that L-lysine can replace amine washing and effectively bind CO_2. Second, they showed that carbamates and bicarbonates also form in this process in the lab. "And when we hydrogenate these substances, that is, add hydrogen and a catalyst, we get formates," Henrik Junge explains.

In this way, and this is the innovation of the process, they were able to process the carbon dioxide obtained in the laboratory in one go, so to speak, into a useful, long-lasting product. And they were able to do so even at extremely low CO_2 concentrations from the air and with the help of the sustainably produced starting materials L-lysine and hydrogen.

SAW project of the Leibniz Association

The research work is part of the joint project "Supreme", which is financed by research funds from the Leibniz Association. In addition to LIKAT, two other Leibniz institutes in Greifswald (INP) and Bremen (IWT) are involved. The aim is to hydrogenate carbon dioxide from the air into methanol. The LIKAT chemists are currently ending up halfway with the formates, but it is such an "encouraging result," according to Henrik Junge, that CHEMICAL SCIENCE put this story on the cover of its issue.

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Original publication:
DOI: 10.1039/d1sc00467k