

PRODIGY – Process development in gas-solid photocatalytic CO₂ reduction

CO₂ as a sustainable source of carbon – Pathways to industrial application (CO₂-WIN)

The project “PRODIGY” aims to use CO₂ in light-driven (photocatalytic) processes as the starting point for the direct production of valuable substances. The aldehydes, alcohols, or acids produced in this way can find their way into the chemical production chain as chemical intermediates. This approach allows the integration of carbon dioxide in chemical production in the form of a circular carbon economy instead of being emitted. The project is funded as part of the funding measure “CO₂ as a sustainable source of carbon – Pathways to industrial application (CO₂-WIN)”. The measure supports projects that utilize carbon dioxide as raw material for the German economy.

Sustainable products from CO₂ and light

The use of CO₂ to produce fine chemicals and fuels offers an excellent solution to combat global warming and the energy crisis at the same time. Solutions for this problem are searched intensively worldwide. In “PRODIGY”, the partners produce (nano) materials which, as so-called photocatalysts, can convert CO₂ into useful products in an environmentally friendly manner using sunlight. This “artificial photosynthesis” is not an easy process, since CO₂ is an extremely stable and unreactive molecule.

Measured against the state-of-the-art in academic research, the yields and reaction rates must be increased by orders of magnitude to be of industrial interest. The researchers now want to manufacture products of higher value, such as lower alcohols, aldehydes, or carboxylic acids, so that even low reaction rates become economically attractive. The production of synthesis gas (CO + H₂) would be an alternative starting point for an industrial value chain. To achieve the target reactions, additional reaction partners must be supplemented, which should preferably be obtained from biogas, so that the process remains sustainable. Therefore, the strategic design of the materials, the reaction engineering-based optimization of the experimental parameters, and an approach to life cycle analysis are crucial for the project’s success.

Innovations in material design and process concepts

The main innovative approaches of the project can be divided into three categories: First, the synthesis of nano materials that can use as much sunlight as possible is a critical aspect for increasing efficiency. In addition, the ability of the materials to bind CO₂ is another crucial factor. Second, the formation of valuable products from CO₂ often requires reactions at high temperatures.



“PRODIGY” optimizes artificial photosynthesis for the usage of carbon dioxide.

For example, synthesis gas is produced from CO₂ and CH₄ at more than 600 degrees celsius.

The strategic design of materials with catalytic and light-absorbing properties enables the combination of heat and light, so that the reactions take place at lower temperatures and valuable energy is saved. Completely new reaction paths also become accessible. Third, the life cycle-related assessment of environmental properties and costs (life cycle assessment and life cycle costing) provides crucial information about the processes developed in “PRODIGY”, whereby their scaling to an industrial scale is taken into account. This ensures that the processes developed are truly sustainable.

Broad expertise in a strong consortium

The consortium jointly pursues the three innovative approaches mentioned above. Researchers of the Technical University of Berlin and the Carl-von-Ossietzky-University of Oldenburg develop new tailor-made photocatalysts with the required properties (optoelectronic and structural), primarily based on inexpensive carbon nitride. The use of critical raw materials is largely avoided.

The academical groups of the coordinating Leibniz-Institut für Katalyse e. V. at the University of Rostock, the Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, and the Technical University of Berlin test the manufactured materials, optimize the reaction conditions, evaluate the most important structural and electronic properties, and give feedback to improve efficiency and to form products of higher value.

Researchers of the Institute for Technology Assessment and System Analysis at the Institute for Technology Karlsruhe perform sustainability studies to enable the partners to concentrate on ecologically and economically sensible ways already from the project start. The project's results, materials, and optimized processes should ultimately be of interest to the chemical industry as environmentally friendly alternatives.



The "PRODIGY" photoreactor.

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CO₂ as a sustainable source of carbon –
Pathways to industrial utilization (CO₂-WIN)

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