Federal Ministry of Education and Research

CO_2WIN Use Carbon Sustainably

DEPECOR – Direct efficient photoelectrocatalytic CO_2 reduction

CO_2 as a sustainable source of carbon – Pathways to industrial application (CO_2-WIN)

The project "DEPECOR" aims to reduce the CO_2 concentration released into the atmosphere by using renewable energy sources for the production of solar fuels. For this purpose, the project partners intend to develop an "artificial leaf" in the form of a multi-absorber demonstrator, which can efficiently reduce CO_2 through non-assisted, direct, and sunlight-induced photoelectrocatalysis in an integrated system and to convert it into hydrocarbons as storable energy sources. The project is funded as part of the funding measure "CO_2 as a sustainable source of carbon – Pathways to industrial utilization (CO_2-WIN)". The measure supports projects that utilize carbon dioxide as raw material for the German economy.

CO_2 reduction

The emission of greenhouse gases into the atmosphere urgently needs to be reduced, employing carbon-neutral, renewable technologies. The main focus is the concentration of carbon dioxide (CO_2), which accumulates in the atmosphere and needs to be reduced either by extraction from the environment (air, oceans) or directly from industrial processes.

The current efforts can be divided according to their expected timeline: While the conversion of CO_2 utilizing new chemical methods could take place relatively quickly, the implementation of a technology based on renewable energy is more complex but has been recently shown to be very promising.

The "DEPECOR" project aims to combine highly efficient multi-absorber structures in a systemic approach with structures that have already been established in photovoltaics. Critical interfaces and photovoltages will be adapted for CO_2 reduction, with specific corrosion protection layers and efficient catalysts specially selected according to their material and shape.

The next-generation, innovative device structure

For the non-assisted, direct, sunlight-induced CO_2 reduction, the photoelectrochemical (PEC) cells must generate a photovoltage of approximately 3 V. This is possible with multiple absorber structures based on III-V semiconductors. These PEC cells consist of several stacked semiconductor structures (sub-cells) that absorb the light in different spectral ranges. Thus, effective exploitation of the sunlight spectrum is achieved and the energy losses are significantly reduced compared to single absorber systems. The total voltage is composed of the sum of the voltages of each sub-cell and, therefore, sufficient to drive the chemical reactions directly.

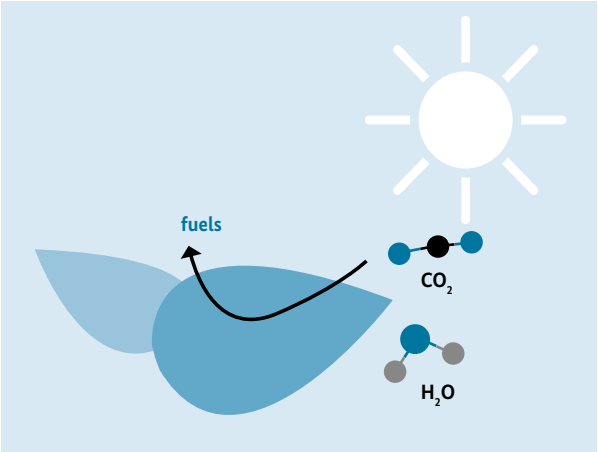
In order to achieve these goals, the "DEPECOR" project will be conducted in five parallel parts: The researchers will advance metallic catalysts, which are selective for the photoelectrocatalytic CO_2 reduction and the oxygen evolution reaction. The catalysts will be transferred to III-V semiconductor test half-cells with thin metal-oxide protective layers. The dynamics of the charge carrier transfer and the interfacial recombination processes will be investigated, and the III-V semiconductor half-cells, catalysts, and protective layers will be optimized. At the same time, the highly efficient multi-absorber cells for PEC will be developed. These will be tested and optimized for a non-assisted, efficient light-induced CO_2 reduction.

New innovative photoelectrochemical cell.

Strengthened national and international networking

TU Ilmenau (TU-IL) group will develop and test an integrated III-V semiconductor, photoelectrocatalytic half-cells. To increase the stability of the cells and enhance

the performance, metal oxide protective layers will be deposited by atomic layer deposition (ALD) at the TU Munich (TUM), and the heterointerfaces will be examined in cooperation with TU-IL. Highly active catalysts will be developed at the Helmholtz-Zentrum Berlin (HZB) and integrated into the cell structure. The interaction of the photocathode with the electrolyte and the quantitative development of the reaction products will be measured at the TUM, HZB, TU-IL, and the Joint Center of Artificial Photosynthesis (USA). The project partner AZUR SPACE Solar Power GmbH (AZUR) will deliver suitable industrially scalable multi-absorber structures on germanium and III-V substrates. At the same time, the Fraunhofer Institute for Solar Energy Systems (ISE) will develop the layer structures on silicon substrates. The associated partner École Polytechnique Fédérale de Lausanne (EPFL) will investigate the activity of specific Cu catalysts and will support the modeling of the prototype of CO_2 reduction systems for non-assisted fuel production. The project partner AZUR and the associated partners BASF and Evonik will advise the prototype development regarding the technology transfer to develop the planned commercial product.



The “DEPECOR” project researches new photoelectrochemical cells for direct, light-induced CO_2 reduction, functioning like an artificial leaf.

Funding initiative
CO_2 as a sustainable source of carbon – Pathways to industrial utilization (CO_2-WIN)

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