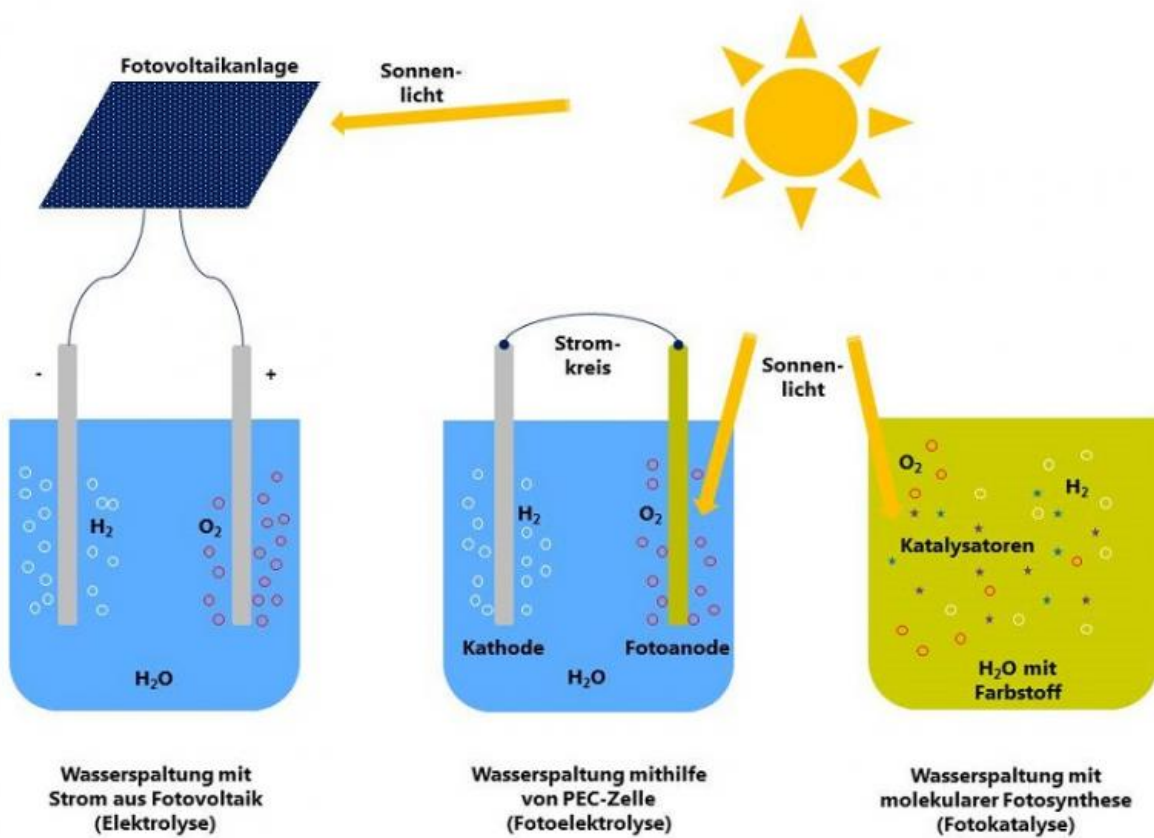


Converting solar energy into chemical energy like nature does

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The researchers make a distinction between three different basic approaches to artificial photosynthesis: Photocatalysis is the closest to natural photosynthesis. However, due to its efficiency advantages, photoelectrolysis in PEC cells is currently the main method used. Credit: Empa

The need for a sustainable energy supply is now a hot topic. Companies are investing in it, and scientists around the globe are looking for alternatives to the production of energy from oil and gas. One such project, which has been running at the University of Zurich since the beginning of 2013, is the large-scale research project, LightChEC. As the name suggests, this university research project focuses on "turning solar energy into chemical energy". The researchers involved are aiming to refine artificial photosynthesis to make it suitable as a means for supplying energy to industry and society. Three Empa scientists, Andreas Borgschulte, Karl-Heinz Ernst and Andreas Züttel, are carrying out research as part of LightChEC. Ernst and Züttel are also on the Steering Committee.

Nature provides the blueprint

Trees, shrubs, grasses and algae have been using photosynthesis since time immemorial. To do this, they create the natural pigment chlorophyll in their [cells](#). The parts of the plant containing chlorophyll convert carbon dioxide (CO₂) and water into oxygen and glucose with the aid of sunlight. The glucose acts as the plant's [energy](#) source and the oxygen is released. This is why forests are often referred to as "green lungs".

Artificial photosynthesis aims to mimic its natural role model. In essence, this is less about the production of glucose, but rather "simply" the separation of water into hydrogen and oxygen using sunlight. The hydrogen obtained can then be used either directly as a fuel, for example, to power fuel cell vehicles, or it can be used to synthesise hydrocarbons, such as methane – the main component of natural gas –, ethane, propane or even (liquid) octane.

The researchers are currently pursuing various ideas for copying natural photosynthesis, as Empa researcher Andreas Borgschulte is doing. In the simplest approach, water is split into hydrogen and oxygen by

electrolysis using solar-generated electricity. The harvesting of sunlight using solar cells and the electrolysis of water are processes that (can) in principle be carried out separately. However, at the microscopic level, they can be combined, as Andreas Borschulte explains. This is referred to as photoelectrolysis in what are known as photoelectrochemical cells, abbreviated to PEC cells. Researchers from Empa unveiled a PEC cell back in 2014. This can be envisaged as a water-filled vessel with a photoanode and a counter electrode. The photoanode absorbs sunlight and provides the electricity to split the water. Therefore, the process does not involve [solar cells](#). PEC cells currently have an efficiency of around five percent. This means that one-twentieth of the [solar energy](#) "captured" is converted into [chemical energy](#) – hydrogen.

Method with potential for the future

Scientists working on the LightChEC project recently succeeded in imitating the whole process in a molecular system in an aqueous solution, thereby removing the need for the electrodes used in PEC cells. With this method, known as photocatalysis, researchers have come a significant step closer to the natural model compared to PEC cells.

However, the efficiency of this method, which was developed as part of LightChEC, is not yet able to match the efficiency of PEC cells. Therefore, the task now is to optimise the various (individual) steps, for example, by further improving the chlorophyll-like dyes or the water-splitting catalysts.

For the time being, however, in addition to their relatively high efficiency, PEC cells offer another advantage: they can already be used today. Also the electrolysis with photovoltaic electricity is already applied, for instance in Empa's "move" mobility demonstrator: with this, Empa aims to show how excess electricity from photovoltaic and hydroelectric power plants can be used efficiently for sustainable

mobility, such as for directly charging electric cars or for producing and storing hydrogen or methane.

The search for better catalysts

Empa researchers have already developed the corresponding method to a large extent, but wish to improve it further. This includes looking for ever better catalysts. These determine, for example, how efficiently CO₂ and hydrogen react to form methane. Using the latest analysis techniques, the Empa researchers want to better understand the mechanisms of these catalysts, i.e. the molecular reaction mechanism, thereby helping to make the production of energy via [artificial photosynthesis](#) commercially viable at some point in the future.

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