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UniCat is supported by the Deutsche Forschungsgemeinschaft (German Research Association) with funding from the Exzellenzinitiative (German Initiative for Excellence) EXC 314.

State Jan 2009

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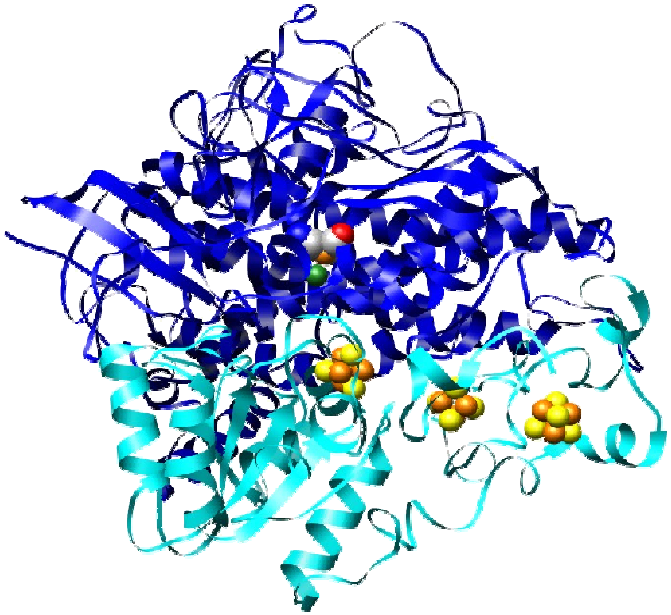
New Biological Sources of Energy

Enzyme-catalysed productions of hydrogen using light and water



Molecular hydrogen is one of the most environmentally friendly sources. Upon combustion with oxygen a great amount of energy is released, and water is the only waste product.

Hydrogen today is produced mainly by steam methane reformation. This process produces climate-destroying carbon dioxide (CO_2). Therefore, biological and bio-inspired processes for hydrogen generation represent attractive long-term alternatives to today's fossil-fuel based energy production. This is where the research of UniCat comes into play.

Based on fundamental findings from basic research, our scientists are developing new strategies for producing hydrogen using light and water.

Creative learning from nature

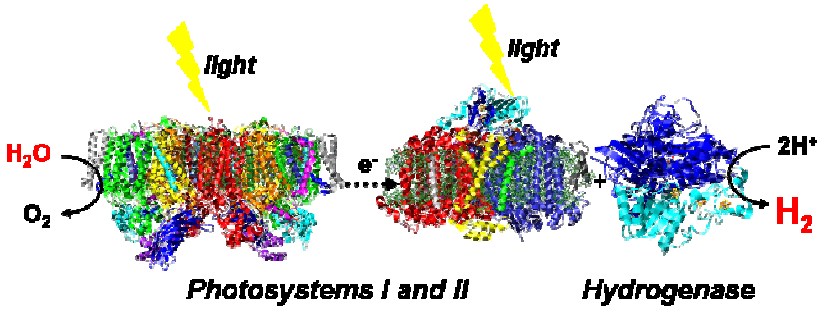
The groups of Professor Dr. Bärbel Friedrich and Dr. Oliver Lenz have developed research strategies with this guiding principle in mind. Both scientists are conducting experimental research at the *Humboldt-Universität zu Berlin*, Institute of Biology/Microbiology.

Generating hydrogen

Both, Friedrich and Lenz collaborate within the UniCat cluster with scientists of the *Technische Universität* and the *Freie Universität* using an interdisciplinary approach. Their ultimate goal is to combine protons and high-energy electrons that are released from the decomposition of water. This reaction is driven by photosynthesis. The required starting resources, water and solar energy can be considered as being abundant on earth. Three complex biological catalysts are involved in the overall process, the photosystems I and II and hydrogenase. Their synthesis, structure and reaction mechanisms are being investigated within the scope of UniCat.

Once the coupling of photosystem I and hydrogenase is being efficiently achieved and the light-driven hydrogen production by fusion proteins has been unambiguously verified, the next step aims at the genetic transfer of the modified hydrogenase genes into photosynthetically active cyanobacteria, and thereby coupling the decomposition of water directly with the production of hydrogen.

Enzyme-catalysed production of hydrogen (H_2) using light and water (H_2O):



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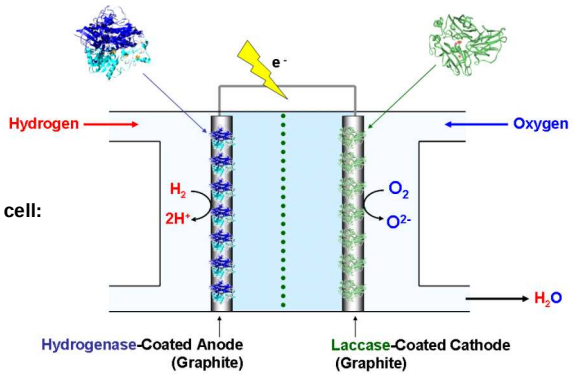
New Biological Sources of Energy

The most fascinating feature of the hydrogenases studied in Berlin is their ability to operate in the presence of oxygen. This property is a fundamental prerequisite for their applicability as biocatalysts in hydrogen technology. This demand accounts for both the production of hydrogen from water and the reverse reaction, the generation electricity from hydrogen and oxygen in a biological fuel cell.

Producing electricity from hydrogen

A miniature model of a biological fuel cell has already been developed in a co-operation with the workgroup of Fraser Armstrong and Kylie Vincent at Oxford University.

Enzymatic fuel cell:



Hydrogen is split into electrons (e^-) and protons (H^+) at one electrode (anode) that is covered with hydrogenase. At the second electrode (cathode), oxygen is reduced to water by the fungal enzyme laccase. The cathode-derived electrons and protons serve along with oxygen as substrates for that reaction. As a result of the reactions at both electrodes a charge separation occurs which induces an electric current. The biofuel cell is even working at low hydrogen concentrations, such as 3% H_2 in air. Great advantages are its independence from the not-sustainable platinum catalyst and its insensitivity towards carbon monoxide. Current investigations focus on the stabilization of the biological catalysts on the electrodes.