Temporary storage for electrons: Natural method of producing hydrogen

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Scientists at the Max Planck Institute for Chemical Energy Conversion (MPI CEC) and the Ruhr-Universität Bochum (RUB) have found through spectroscopic investigations on a hydrogen-producing enzyme that the environment of the catalytic site acts as an electron reservoir in the enzyme. Thus, it can very efficiently produce hydrogen, which has great potential as a renewable energy source.

The research team describes their results in the journal Angewandte Chemie.

The system analysed constitutes an enzyme that catalyses the formation and conversion of hydrogen. In its centre it has a double-iron core, and is therefore also called [FeFe] hydrogenase. Hydrogenases are of great interest for energy research, since they can efficiently produce hydrogen. However, new catalysts can only be developed given a deep understanding of their mode of action.

In hydrogen production, two electrons get together with two protons. The research team showed that, as expected, the first electron is initially transferred to the iron centre of the enzyme. The second transfer on the other hand is to an iron-sulphur cluster that is located in the periphery. It thus forms a temporary storage for the second electron. This "super-reduced" state may be responsible for the extremely high efficiency of the hydrogenase. Subsequently both electrons are transferred in one step from the enzyme to the protons, so that hydrogen is generated. "Only the use of two different spectroscopic techniques made the discovery

possible", says Agnieszka Adamska, a doctoral student at MPI CEC who carried out the spectroscopic studies.

"Up to 10,000 molecules of hydrogen per second can be generated by a single [FeFe] centre", says Camilla Lambertz, a postdoc at the RUB who prepared the biological samples for the project. The enzyme is thus among the most efficient hydrogenases and is therefore also being intensively investigated by biologists and chemists with a view to achieving environmentally friendly hydrogen production. The complete mechanism of hydrogen formation is, however, complex and several steps need to be clarified. Next, the researchers at MPI CEC and the Ruhr-Universität Bochum aim to use sensitive spectroscopic methods to locate the proton to which the two electrons are transferred. This negatively charged hydrogen atom (hydride) reacts with another proton to form hydrogen. Inspired by the [FeFe] hydrogenase, the researchers would like to develop their own hydrogen-producing catalysts that could be used for the generation of hydrogen.

More information: A. Adamska, A. Silakov, C. Lambertz, O. Rüdiger, T. Happe, E. Reijerse, W. Lubitz (2012): Identification and Characterization of the "Super-Reduced" State of the H-Cluster in [FeFe] Hydrogenase: A New Building Block for the Catalytic Cycle?, Angewandte Chemie International Edition, doi: 10.1002/anie.201204800

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