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Photoelectrochemical Water Splitting

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Quantsol was started 25 years ago by the photoelectrochemistry groups in Berlin and Hamburg with the aim to improve discussions between phototoelectrochemists with their electrochemical/chemical background and solid state (semiconductor) physicists working on photovoltaics. One of the main aims at that time had already been the direct storage of solar energy, preferably in the form of hydrogen. Lack of funding especially in Europe stopped most of the early activities until a few years ago, when through massive funding by the Obama government very many new research activities were started.

Meanwhile Photoelectrochemical Water Splitting has again become an important fundamental research topic in today´s research programs mainly in the USA, Japan and China. Not only has the number of research groups in these countries and of the papers published in this field exploded in very recent years (our own documentation of relevant scientific papers in this field contains more than 370 papers for 2011 and more than 350 for 2012 already until September). In the US even targeted research centers were created (The "*Penn State Center for Solar Nano Materials"* near Pittsburgh, PA, "*Powering the Planet"*, a "NSF Center for Chemical Innovation (CCI) for Production of Fuel from Sunlight" in 16 US top-Universities, the Resnick Institute am CALTECH and a Department of Energy (DOE) Energy Innovation Hub in addition to other projects funded by the DOE and the US National Science Foundation. The hub, called the Joint Center for Artificial Photosynthesis (JCAP), will receive $122 million of funding over a period of five years. It is being led by the California Institute of Technology in partnership with Lawrence Berkeley National Laboratory and SLAC National Accelerator Laboratory. A select group of universities is also involved. There are also examples of early stage solar fuels innovation in the US such as the MIT spin-out, Sun Catalytix, (which completed its $9.5 million Series B Funding Round, led by Tata Limited in 2010), the University of Toledo spin-out Midwest Optoelectronics Solar and the Princeton University spin-out, Liquid Light, as well as larger companies participating, such as Directed Technologies Inc., and United Solar Ovonic.

A Korean Centre for Artificial Photosynthesis (KCAP) was launched at Sogang University in 2009 and, the following year, signed a memorandum of understanding on international research with the Solar Energy Research Centre (SERC) of the Lawrence Berkeley National Laboratory in the US. In 2011, the center made a cooperation agreement with steel company POSCO to undertake joint research on the commercialization of artificial photosynthesis. POSCO is constructing a dedicated building, due to be completed in 2012,

for this research program.

In China, the Institute for Clean Energy was recently inaugurated and forms part of the Chinese Academy Institute of Chemical Physics in Dalian.

In 2007, the Japanese government launched its World Premier International Research Center Initiative. Each multidisciplinary basic research area receives around ¥1.4 billion per year over a 10 to 15 year period to create centers for research. The most recent center to be announced is the International Institute for Carbon-Neutral Energy Research in Kyushu. Two other projects within the initiative – the International Center for Materials Nanoarchitectronics and the Advanced Institute for Materials Research – also include research related to artificial photosynthesis. Japanese automotive companies are involved in solar fuels research and development. There is an active research program in artificial photosynthesis at Toyota Central R&D Labs and, last year, Honda announced plans to build a second station to produce hydrogen from sunlight and water in Saitama Prefecture by the end of March 2012.

In Europe the largest single national investment in solar fuels research has been by the Dutch government in a €25 million project, towards BioSolar Cells. This interdisciplinary consortium of six universities is working on solar fuels production by both natural and artificial photosynthesis. It is explicitly set up to build links with existing industry to develop an incubation structure for new business. Other projects include the European Science Foundation's EuroSolarFuels program and SOLARH2, led by Uppsala University in Sweden, which received approximately €4 million under the European Commission's Seventh Framework Program (FP7) for research. Other projects funded as part of FP7 are Nanostructured Photoelectrodes for Energy Conversion (NANOPEC), at €3.94 million, and Nanodesigned Electrochemical Convertor of Solar Energy in Hydrogen Hosting Natural Enzymes or their Mimics (SOLHYDROMICS), at €3.65 million, and Design of Hybrid Nanostructured Bio-photocatalyst for Their Application in Bio-photoelectrochemical Hydrogen Production (SOLAR BIO-HYDROGEN), at €18103.

Germany`s BMBF finances an "excellence cluster" of 6 research groups in the project Light2Hydrogen. It is supported by the project *"Nanostrukturierte Materialien für die Wasserstofferzeugung"* (Nano4Hydrogen) financed with one million euros by the state of Mecklenburg-Vorpommern, Germany, through the ESF program funded by the European Union. The project will be running for three years starting in 2009.

In Denmark the Center for Atomic-scale Materials Design (CAMd), Department of Physics, Technical University of Denmark works on photoelectrochemical water splitting. The UK Solar Fuels and Artificial Photosynthesis report lists several targeted research projects funded by in total more than 15 million British Pounds.

The different aims of these projects will be discussed in the talk and compared with the results obtained already in "the old days". A main focus will be on cost and area requirements of systems contributing considerably to the world power demand.