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SUNtoX
Solar Energy for Carbon-Free Liquid Fuel

PROJECT OVERVIEW

Work packages updates

WP1 Photoanode (WP Leader: Helmholtz Zentrum Berlin)

Development of porous photoanodes as top absorber in the PEC device.

Several potential photoanode candidates were investigated in WP1. Since $BaTaO_2N$ and $LaTiO_2N$ photoanodes consistently showed poor performance, further efforts were focused on $BiVO_4$. Existing electrodeposition recipes were found to result in inhomogeneous coverage and poor performance when depositing $BiVO_4$ onto transparent porous conducting scaffold. By modifying the recipe and utilizing a pulsed electrodeposition scheme, the homogeneity could be greatly improved, resulting in photocurrents of 1.1 mA/cm^2 at 1.23 V in the presence of a hole scavenger. To ensure good stability and high oxygen evolution activity of the films in an acidic environment, $BiVO_4$ model films on flat substrates were successfully modified with ultrathin (~5 nm) TiO_2 protection layers made by atomic layer deposition and an IrO_x oxygen evolution catalyst deposited using photoelectrochemical deposition.
Next Steps: optimization of the pulsed deposition recipe will be carried out in order to further improve the photocurrents. The recipes developed for the deposition of the TiO_2 protection layer and the catalyst will be transferred to the porous $BiVO_4$ photoanodes and scaled up for integration in the demonstrator device.

WP2 Photocathode (WP Leader: Ecole Polytechnique Federal de Lausanne)

Development of porous photocathode assemblies that can serve as a bottom absorber in the PEC device.

In the second phase of WP2, hydrogen evolution catalysts (HERs) were integrated with the semiconductor-coated photocathodes prepared on the transparent gas diffusion electrodes. The combination of an organic semiconductor with a Pt HER served as a benchmark and this demonstrated good performance in the liquid phase and showed an initial promising performance for gas-phase solar driven H2 production (see results in published paper: 10.1002/adma.202208740). Moreover, we demonstrated comparable or even better performance with precious metal-free catalysts including MoS_x and $FeMoS_x$. Coating the HER-functionalized photocathode with ionomer revealed an important limitation of proton transport from the membrane to the active photocathode surface and directed the next steps of the work.
Nest Steps: To overcome challenges with proton transport in the membrane photoelectrode assembly, we are optimizing the morphology of the transparent gas diffusion electrodes in effort to reduce the effective proton transport distance. These optimized electrodes are being produced at large scale for integration in the demonstrator device.

WP3 Membrane Photoelectrode (WP Leader: NWO Dutch Institute for Fundamental Energy Research)

Our efforts in WP3 are focused mainly on the understanding of the water adsorption capacity and degradation mechanisms of the photoelectrode functionalization by ionomer coatings. The drop casting of Aquivion ionomer has led to high gas phase performance recovery, when compared to the liquid operation, however, the stability is still not satisfactory. We have attributed the degradation to the high levels of the UV illumination that we implement for evaluating the coatings dynamic water adsorption capacity.
We are currently evaluating methods on applying our coatings in the transparent porous conducting substrates (TPCS) as an attempt to prepare the ground for the functionalization of the optimized photoelectrodes from WP1 and 2 (that are developed on TPCS).

WP4 Liquid chemicals (WP Leader: HySiLabs)

Development of efficient and cost effective procedure and reactors to charge HydroSil with hydrogen and test its potential for the depolymerisation of waste plastics.

During the first period leading to February 2022, the best pathway for the charging process was identified, and design of the 3 sub-systems had begun.

During the second period of the project (Mar 22-Feb 23), all sub-systems involved in the charging process have been designed according to the scale of the Sun-to-X project. The solar concentrator and heat exchange devices have been identified and their interconnexion with the charging process designed.
Hydrosil has been produced and supplied to CEA for continuing their activities on the Depolymerization of waste plastics to chemicals and liquid hydrocarbons.

Finally, first trials have been carried out to chemically reduce waste plastics to hydrocarbons and fuels, using HydroSil to provide hydrogen as main reactant.
Through the assessment of various solvents and catalysts, we have been able to produce hexane with a 55% yield.

WP5 Demonstrator (WP Leader: ENGIE)

In WP5, we had planned to build a demonstrator for the synthesis of HydroSil. Unfortunately however, after the preparation of the process flow diagrams and corresponding safety studies. due to the technical and safety requirements for the handling and storage of the silicon chloride species, which are generated as reaction intermediates, the cost to build such a reactor on a demonstrator scale was out of the scope of the project.
We note, that these chemicals are used in the chemical industry on a large scale, so the future scope for HydroSil synthesis remains promising. We are now investigating if it is possible to build a simpler reactor for the synthesis of an alternative silicon hydride (trimethylsilane) to demonstrate a value-chain going from green hydrogen production and storage in silicon hydride bonds.

The project so far

Project highlights, updates and latest news

A STEP TOWARDS SOLAR FUELS OUT OF THIN AIR

EPFL chemical engineers have invented a solar-powered artificial leaf, built on a novel electrode which is transparent and porous, capable of harvesting water from the air for conversion into hydrogen fuel. The semiconductor-based technology is scalable and easy to prepare.

Read more

FOLLOW THE CAMPAIGN

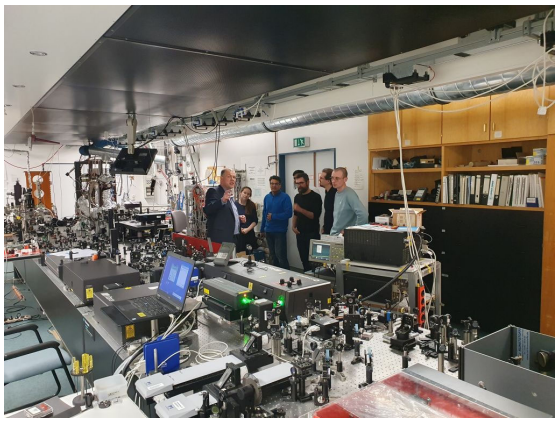
The Sun-to-X project partners have recently launched a new communication campaign aimed at raising awareness of their groundbreaking research and development work in the field of renewable energy.

Follow us on Twitter and Linkedin

SUN-TO-X CONSORTIUM MEETING IN BERLIN

The Sun-To-X consortium recently held a successful meeting to discuss their progress in developing a sustainable system for renewable hydrogen production using solar energy. During the meeting, partners reported their work package progress and visited the Helmholtz-Zentrum Berlin Lab!

Read more



USING SOLAR ENERGY TO PRODUCE A CARBON-FREE LIQUID FUEL

We are excited to share this brand new article about the Sun-To-X project featured in Innovation News Network, written by our coordinator Hannah Johnson from Toyota Motor Europe.

Read more

THE 10TH ANNUAL EDITION OF SUSTAINABLE PLACES CONFERENCE

As part of Sustainable Places 2022 in Nice, a workshop on Low-TRL Renewable Energy Technologies was held. Luc Berman from LGI Sustainable Innovation presented methodologies and strategies adopted within the Sun-to-X project to address those issues.

Read more

Events

Sun-To-X partners will gather in Lausanne to discuss on the last stage of the project!

An international consortium

26/08/2021

SUN-to-X Solar Energy for Carbon-Free Liquid Fuel

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The Sun-To-X project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 883264.