Review of the Photo4E Scientific Conference, 15-17 Oct 2014, Solaize

Photocatalysis, used as a method of producing electrical or chemical energy, has developed considerably over recent years. In particular, significant research has been conducted in the field of hydrogen production via water photolysis, the production of recyclable hydrocarbons by CO_2 reduction and the production of electricity using dye-sensitized solar cells. The different strategies identified are photocatalysis (or catalytic photochemistry), photosensitized photocatalysis and photoelectrocatalysis.

The program for the Scientific Conference hinged around three themed sessions and a more forward-looking final session. The major trends and a few of the key elements to emerge from the oral presentations, including keynote lectures, are summarized below.

<u>Session 1</u>: Photocatalytic materials: emerging concepts from photocatalytic synthesis

In this field, the main research avenues concern 1/ the modification of the intrinsic properties of semiconductors 2/ the quest for new composite architectures or structures generating specific heterojunctions, and 3/ the use of new molecular complexes as a photosensitizer. The phenomena that need further optimization and are the focus of numerous research programs include, among others: band-gap engineering, the recombination of photo-generated charges, trapping of these charges by a co-catalyst and their transport inside the semiconductor, the adsorption of reagents (e.g. CO_2) and surface plasmon resonance.

A review of solar fuels opened this session, which included, in particular, a technical and environmental analysis of photo-electro-catalysis (PEC) for the production of molecular hydrogen (H_2). Concerning new formulations, aimed either at water photolysis or CO_2 reduction, the solutions studied pursue a range of objectives: cost reduction, performance improvement or the elimination of toxic compounds by substitution of current components.

<u>Session 2</u>: Comprehensive studies on mechanisms and kinetics

Numerous sophisticated investigation techniques, including *operando*, were used in the research presented, which focused on understanding the systems in operation: identification of electron production and trapping mechanisms, observation of chemical species formed, determination of the lifespan of excitons, etc. Research also made use of ab-initio molecular modeling to rationalize phenomena.

Session 3: Characterization techniques, engineering, processes

The various techniques presented include:

- the RPES (Resonant Photo Emission Spectroscopy) technique, which, in the case of a photo-electrochemical cell destined for water photolysis via OER (Oxygen Evolution Reaction), has made it possible to gain access to the electron structure of the hetero-junctions of thin layers and to identify the presence of defects promoting an unwanted recombination of charges.
- operando X-ray absorption, used to monitor modifications in the electron and structural properties of the Pt supported on TiO_2, and making it possible to measure the increase in electron density of the Pt_{5d} orbitals with light intensity and wavelength.
- FM-AFM (Frequency Modulation-Atomic Force Microscopy), a developing operando technique used to study molecular adsorption on a surface and, for example, explain the hydrophilicity of a TiO_2 surface induced by UV exposure.

In addition, innovative systems and principles were described, including:

- the use of the interface between two non-miscible electrolytes, as an environment conducive to the realization of a (photo)-electrochemical reaction, due to the homogeneity of its surface, the absence of defects and the possible separation of reagents and products formed.
- a combined system, incorporating a photocatalytic reagent for the production of H_2 via alcohol dehydrogenation and a PEM fuel cell: the system has been shown to work, but significant improvements are still required in terms of performance.
- a photochemical cell, composed of two compartments separated by a proton-conducting membrane, and designed to produce electricity via the UV photolysis of water.

Session 4: Future opportunities in photocatalysis for energy

The final session was devoted to more forward-looking presentations, such as:

- the use of molecular complexes for water photolysis
- the use of MOF (Metal-Organic Frameworks) for the photoreduction of CO_2
- the rational design of photo-electrochemical cells with a view to their larger-scale development.

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64 participants, mostly university researchers, from around the world (more than fifteen nationalities represented) attended the conference.

A selection of papers will be published in a dedicated issue of OGST, the free on-line review of IFP Energies nouvelles.