Challenges in Solar Detoxification of Industrial and Urban Wastewater and the Simultaneous Production of Renewable Energy

by

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Abstract

Solar water detoxification is a feasible and potentially low-cost method for the removal of toxic contaminants, micropollutants and emerging contaminants (ECs) from the environment. These include sub-ppm levels of cyano-toxins, estrogens, pharmaceuticals, personal care products, pesticides and many other ECs, as well as dissolved biomass. The process of solar water detoxification can be coupled to the simultaneous production of hydrogen to yield a sustainable approach for environmental remediation and renewable energy production. In such process, solar light energy is harvested by a suitable semiconductor and/or plasmonic photocatalytic materials which is able to produce excited states into the materials that can drive oxidation of organic waste and simultaneous reduction of heavy metals and water to hydrogen.

In this lecture the challenges related to the synthesis of material with high solar-harvesting efficiency, the engineering, design and scale-up of such combined process, modeling aspects, laboratory and pilot-scale demonstration studies are presented to open up new avenues for a sustainable approach to renewable energy production and environmental protection. The production of renewable hydrogen and/or electricity from the treatment of industrial and urban wastewaters is demonstrated through the use of modified and novel photocatalytic materials (Ag/TiO₂ and plasmonic Ag/AgCl @ chiral TiO₂ nanofibers) and their deployment in solar powered photoreactors and photo-fuel cells at pilot and laboratory scale.

Finally, a disruptive microfluidics platform technology for extremely fast and efficient phototransformation of chemical and biological species is presented. This is based on the fabrication of fluoropolymer microcapillary films (MCF) which are fully transparent to the entire spectrum of incident light, from the visible to the UVC. The unique fluid-dynamics and optical properties of the MCF makes it ideal for exploring the phototransformation of CECs and controlled substances, for the identification of transformation by-products and for the formulation of reaction mechanisms, particularly from very small volumes of highly-priced chemical compounds, metabolites or intermediates, which are currently unrealizable using other photo-irradiation systems.

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