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Photoanodes made from 2D tin sulfide nanosheets enhance the visible light absorption of photoelectrochemical devices

In a new study published in the *International Journal of Hydrogen Energy*, researchers demonstrate the potential of solution processed photoanodes made of 2D tin sulfide (SnS₂) nanosheets in photoelectrochemical (PEC) Systems by showing its ability to absorb and convert visible light into chemical energy. The results establish them as promising materials for enhancing PEC applications, including solar fuels and hydrogen production.

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Photoelectrochemical (PEC) water splitting and CO₂ reduction based on solar energy is a promising approach for the production of green hydrogen and the conversion of CO₂ into renewable fuels or feedstock. However, the deployment of PEC systems is limited by the excessive band gaps of metal oxide photoanodes, which do not allow efficient visible light absorption. Mid and large band gap materials suitable for tandem applications remain difficult to find due to their cost, scarcity of abundant materials, or low efficiency.

Recently, 2D atomically thin transition metal chalcogenides (TMCs) such as WS₂, WSe₂, MoS₂, and MoSe₂ have become the center of attention for their efficiency, tunability, and low cost, making them suitable for PEC applications as absorbers with shorter band gaps and also as catalysts for hydrogen and oxygen evolution reactions. Among these materials, tin sulfides (Sn_xS_y) have attracted interest due to the abundance of tin and sulfur, their fabrication simplicity, semitransparency, and enhanced photocatalytic activity.

In this new study, ICFO researchers and SOREC2 team members, **Jordi Martorell** and **Carles Ros**, in collaboration with **Yudania Sanchez**, **Maxim Guc**, **Maykel Jimenez -Guerra** and **Alejandro Perez-Rodriguez** from Catalonia Institute for Energy Research (IREC); **Sara Marti-Sanchez** and **Jordi Arbiol** from Catalan Institute of Nanoscience and Nanotechnology (ICN2); and **Shadai Lugo-Loredo** from Universidad Autonoma de Nuevo Leon (UANL), describe the fabrication and optimization of photoanodes made from 2D tin sulfide (SnS₂) multilayer nanosheets using solution-processed techniques. Their work, recently published in the *International Journal of Hydrogen Energy*, reveals for the first time the visible light

absorption and conversion capabilities of these 2D SnS₂-based photoanodes.

The researchers fabricated the photoanodes using a two-step, solution-based process. At the nanoscale, samples fabricated with the highest annealing temperature (500 °C) exhibited well-defined, multilayer, 2D hexagonal SnS₂ nanosheets exceeding 400 nm in width. This phase also displayed the smallest electronically active bandgap, improving the material's ability to convert visible light into electrical energy.

The scientists further evaluated the photoelectrochemical capabilities of the fabricated SnS₂ layers, employed as photoanodes for the oxygen evolution reaction (OER) in a single-compartment water splitting cell. After optimizing post-treatment procedures, the researchers obtained SnS₂ nanosheet samples that generated photovoltages exceeding 1.0 volts and photocurrents surpassing 1.6 mA/cm². Additionally, they measured the incident photon-to-current conversion efficiency (IPCE) of these enhanced SnS₂ samples. The researchers observed photon conversion by the SnS₂ nanosheets across the 500-900 nm range (visible spectrum), with a maximum IPCE of 75% at 330 nm.

The observed IPCE profile indicates that SnS₂ 2D nanosheet photoanodes fabricated using solution-processed means have a significant potential for enhancing absorption and conversion across the entire visible light spectrum, positioning them as promising materials for efficient solar hydrogen production. The authors wrote, "Our work contributes to a better understanding of transition metal sulfides as 2D photo-absorber materials in photoelectrochemical conditions." Carlos Ros, co-author of the study.

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