

Visible light photoelectrochemical purification of water by WO₃ thin films

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WO₃ films of 10 cm x 10 cm with a thickness between 0.8 and 1 μm on optically transparent, electrically conducting substrates were used for the study of degradation reactions of model substances for contaminants like oxalic acid and 4-chlorophenol dissolved in water at millimolar starting concentrations. An electrochemical thin film reactor with small distance between working and counter electrode turned out to be necessary for minimizing the supporting electrolyte concentration required for driving reasonable photocurrents (limitation of Ohmic drop across the electrolyte), which will especially be important in the case of drinking water purification.

With backside illumination (which is a requirement for operation in a thin film reactor), using broadband UVA illumination, the TOC (total organic carbon) content of oxalic acid and 4-CP solutions was shown to be decreased down to a level of 1 ppm carbon (w/v) when moderate bias (< 2 V) was used. Without bias, the reaction rate was smaller by a factor of forty.

During the course of the reaction, the concentration decreases exponentially in batch mode, since the Faradaic efficiency decreases with decreasing concentration of contaminant, but the advantage over operation without bias (conventional photocatalysis) prevails.

UVA and daylight-type lamps were used for typical experiments, but it was shown that comparable photocurrents could be drawn using solar light, leading to comparable degradation efficiencies, which is interesting in view of a standalone purification unit for water purification. Sensitivity to visible (solar) light represents the main advantage of WO₃ over TiO₂, the presently most widely used depollution catalyst.

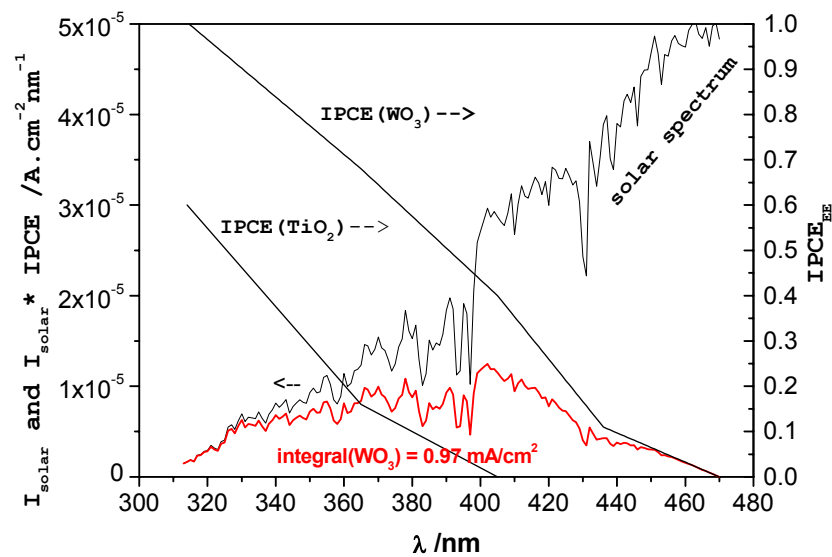


Fig. 1: Comparison of TiO_2 with WO_3 . IPCE for junctions with an aqueous electrolyte as a function of wavelength, solar spectrum, and $\int \text{IPCE}_\lambda \cdot I_{\text{solar},\lambda} \cdot d\lambda$ for the case of WO_3 . Electrolyte: 0.1 M HClO_4 , $E = 1.2 \text{ V vs. SCE}$.

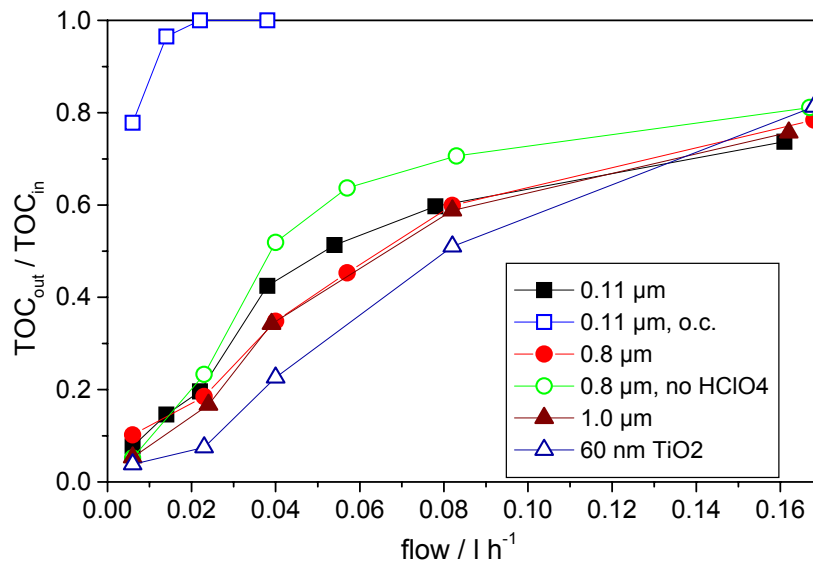


Fig. 2: Oxalic acid degradation (initial concentration 1 mM) in flow-through mode under UV light illumination using tungsten trioxide electrodes of different thickness (and for comparison a titanium dioxide electrode) under electrical bias (and in comparison without bias). TOC ... total organic carbon.