Single-particle photoelectrodes: inter-facet and intra-facet differences

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This presentation will describe our recent work in using single-particle/single-molecule imaging approaches to study (photo)(electro)catalysis on nano- and micro-scale particles. I will first give some background on single-molecule, super-resolution fluorescence imaging of catalytic reactions on single catalyst particles, with some examples. I will then focus on a recent study of photoelectrocatalytic properties of particulate semiconductor photocatalysts, important for many solar energy conversion technologies. In anisotropically shaped photocatalyst particles, the different constituent facets differ in their electronic and thus photoelectrocatalytic properties, and between different facets they may form inter-facet junctions at their adjoining edges, analogous to lateral two-dimensional (2D) heterojunctions or pseudo-2D junctions made of few-layer 2D materials. Using subfacet-level multimodal functional imaging, we uncover inter-facet junction effects on anisotropically shaped bismuth vanadate ($BiVO_4$) particles and identify the characteristics of near-edge transition zones on the particle surface, which underpin the whole-particle photoelectrochemistry. The imaging tools, the analytical framework and the inter-facet junction concept pave new avenues towards understanding, predicting and engineering (opto)electronic and photoelectrochemical properties of faceted semiconducting materials, with broad implications in energy science and semiconductor technology.