Voltage-Driven Water-Dissociation Catalysis: Fundamentals to Applications Advanced Bipolar Membrane Technology

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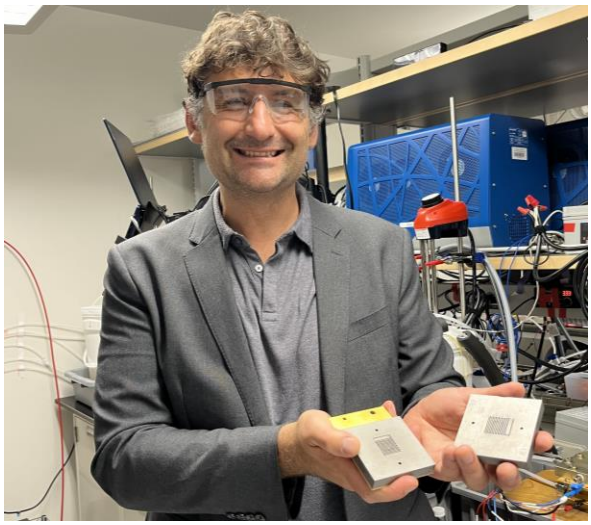
Reactions of water typically involve breaking H-O bonds and are ubiquitous in biological, industrial, and environmental processes. The simplest reaction is heterolytic water dissociation (WD), $H_2O \rightarrow H^+ + OH^-$, the understanding of which has been a focus of experiment and theory for decades. We use a bipolar-membrane (BPM) electrolyzer, where WD is driven in the region between a hydroxide-exchange and proton-exchange membrane by an applied voltage, to study WD kinetics. We apply various electrochemical platforms to study the basic factors and mechanisms that control the kinetics of WD, discovering how tuned metal-oxide nanoparticles provide surfaces with (controllable) proton-absorption sites that catalyze WD while also focusing the interfacial electric field across the BPM junction to speed the WD rate (e.g. *Science* 2020, *Nature Comm.* 2022). Temperature-dependent measurements show the WD catalysts do not primarily lower the activation energy for WD, but instead dramatically increase the number of water configurational microstates poised for the proton-transfer elementary steps in WD (*Joule*, 2023). These discoveries enabled the design of new WD catalysts for BPMs that operate with 40-times better voltage efficiency than the commercial state of the art (*Nature Materials*, 2024), and at current-densities of up to 4 A/cm^2, driving commercialization efforts for advanced bipolar membranes and new applications.



Biography: Boettcher is a Professor in the Departments of Chemical Engineering and Chemistry at the University of California, Berkeley, and the Deputy Director for the Energy Storage and Distributed Resources Division at Lawrence Berkeley National Laboratory. From 2010-2023 he was at the University of Oregon where he founded the Oregon Center for Electrochemistry. His research is at the intersection of electrochemical science and engineering, and materials chemistry, with a focus on fundamental to applied aspects of energy conversion and storage. In 2023 he was the Blavatnik National Award Laureate in Chemistry. He founded the first graduate program in Electrochemical Technology in the USA, and is currently building the Center for Electrochemical Science, Engineering, and Technology (CESET) in Berkeley to drive electrochemistry as a core discipline to address humanities biggest challenges.