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Selective Electrochemical Oxidation for Chemical Synthesis and Fuel Generation

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Electrolysis systems are used for on-site gas generation and renewable energy storage, but can also be used reduce the cost of oxidative chemical synthesis by reducing sacrificial reagent utilization. In a typical water electrolysis system, electricity is stored in the chemical bonds of hydrogen gas, which is formed by proton reduction at a cathode with concomitant oxygen production via the water oxidation half-reaction at an anode. While this technology has been in use in laboratories for decades, its successful implementation has not been realized on large scales in the energy industry due to the low cost of hydrogen derived from natural gas. Therefore, new value propositions and uses need to be found for this type of technology to achieve commercial deployment in the near-term. Using a polymer electrolyte membrane (PEM) electrolyzer, we show that this technology can be used to selectively remove or alter organic contaminants in water. This has widespread applications in both wastewater treatment and chemical synthesis for drug development. By further studying mechanisms of small molecule oxidation in a three-electrode electrochemical cell, we are able to explain phenomena observed in commercial-scale systems and guide our design to identify new, efficient, robust, and selective oxidation catalysts. Evidence for new iridium-catalyzed pathways for small molecule oxidation is shown in proof-of-concept experiments, and applied in a wide range of commercial applications including chemical synthesis and wastewater purification.

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