

Paired Electrochemical Hydrogenation and Oxidation of Biomass-Derived Furanic Compounds to Value-Added Monomers in the Single Electrolyzer

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Abstract: Organic electrosynthesis is emerging as a cost-effective and environmental-friendly chemical production strategy by utilizing renewable electricity. Paired electrolysis cogenerates valuable chemicals at both electrodes can optimize the energy efficiency and economic feasibility. We report pairing hydrogenation and oxidation of 5-(hydroxymethyl)furfural (HMF) or furfural to desired chemicals at a single electrolysis cell. Electrocatalytic hydrogenation of HMF to 2,5-bis(hydroxymethyl)furan (BHMF) and furfural to furfural alcohol (FA) with high selectivity of >90% can be operated at near-neutral pH on Ag-based and Pb-based catalysts, respectively. In addition, oxidizing HMF to 2,5-furandicarboxylic acid (FDCA) and furfural to furoic acid can both be realized at TEMPO mediated process by using carbon-based catalysts or at Ni-based catalyst in an alkaline medium. Taken together, HMF or furfural can be performed in a single electrolysis cell with a minimized cell voltage only around 1.6 V. Products selectivity and faradaic efficiency are highly related to the reaction conditions, including potential or current density, architectures of the reactor, type of catalysts. By optimizing the single flow reactor, a three-electrode system, two-electrode membrane assembly architecture, and pH-symmetric and pH-asymmetric structure can be designed to reduce the capital expense, minimize required energy, and simplify processing steps. Finally, a complete electrons economy can be achieved by pairing two electrochemical reactions, and the overall charge efficiency can attain over 170% without any crossover issue detected. As a result, the continuous cogeneration of high value-added BHMF or FA and FDCA or furoic acid can be performed in a single electrolyzer.