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Efficient Oxygen Evolution and Gas Bubble Release by a Low-Bubble-Adhesion Iron-Nickel Vanadate Electrocatalyst

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Abstract : Improving surface chemistry is a promising approach in addition to the rational alteration in the catalyst composition to advance water electrolysis. Here, we demonstrate an evident enhancement of oxygen evolution on an iron-nickel vanadate catalyst synthesized by a facile successive ionic adsorption and reaction method. The vanadate-modified catalyst demonstrates a highly efficient oxygen evolution in 1 M KOH by requiring low overpotentials of 274 and 310 mV for delivering large current densities of 100 and 400 mA cm^{-2}, respectively where vigorous gas bubble evolution occurs. Vanadate modification augments the OER activity from three aspects. (i) Both the electrochemical surface area (47.1 cm^2) and intrinsic activity (318 mV to deliver 10 mA cm^{-2} per unit ECSA) of the catalytic sites are improved. (ii) The amorphous and roughened nanoparticle-comprised catalyst film exhibits a high surface wettability and a low-gas bubble-adhesion, which is beneficial for the accelerated mass transport and gas bubble dissipation at large current densities. The gas bubble dissipation behavior is studied by operando dynamic specific resistance measurements where a significant change in the variation of the interfacial resistance during the OER is detected for the vanadate-modified catalyst. (iii) The introduced vanadate poly-oxo-anions with high charge density have electronic interplay with Fe and Ni catalytic centers. Raman study reveals the structural evolution of β-NiOOH and γ-FeOOH phases during the OER through the vanadate-active site synergistic interactions. Achievement of a high catalytic turnover of 0.12 s^{-1} put the developed FeNi vanadate among the best recent catalysts for water oxidation.

Keywords : gas bubble dissipation, iron-nickel vanadate, low-gas bubble-adhesion catalyst, oxygen evolution reaction
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