ELECTROCHEMICAL DESIGN OF INTERLAYER $Co(OH)_2$ -NiFe ELECTRODES TO TUNE REDOX AND ADSORPTION PROCESSES FOR EFFICIENT OER

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To meet the Greener Europe initiative, there is a need for efficient and industrially viable renewable energy sources, and electrochemical water splitting is one of the cleanest emerging methods for producing hydrogen. However, the oxygen evolution reaction (OER) is kinetically sluggish and is the bottleneck in alkaline water electrolysis, for which more efficient and consistent catalysts with lower overpotentials, higher current density, and chemical stability are required [1-3]. Among non-noble metal candidates, NiFe oxides and (oxy)hydroxides have gained attention due to their efficient alkaline OER, low cost, and favorable redox chemistry. In spite of having outstanding OER characteristics, they are often limited by poor electrical conductivity and poor long-term stability. In this study, the broader shift from “material-only” to electrode architecture engineering was primarily explored, in which a $Co(OH)_2$ sponge interlayer is electrochemically deposited on the Cu electrode, followed by the deposition of a NiFe framework. The NiFe framework was optimized by adjusting the deposition voltage through measurement of the representative composition using EDX after each deposition. Successful deposition of $Co(OH)_2$ interlayer and NiFe top layer was confirmed using the SEM and elemental area mapping. Improved OER catalytic activity of the NiFe system was achieved upon incorporation of $Co(OH)_2$, yielding an overpotential of 261 mV at the current density of 10 mA cm^{-2}, and a Tafel slope of 47 mV dec^{-1}. EIS studies revealed that the double-layer capacitance was increased with the incorporation of $Co(OH)_2$, i.e., from 0.06114 Fcm^{-2} for NiFe1.5 alone to 0.11 Fcm^{-2} for NiFe1.5@C1, signifying the synergy between the NiFe and $Co(OH)_2$ interlayer. The presence of $Co(OH)_2$ was further confirmed by Raman spectroscopy, and Fe was observed to exist as Fe_3O_4 at higher deposition amounts. The absence of metallic Ni or Fe signals in XRD suggested the formation of a mixture of amorphous-like oxides and hydroxides. Overall, this study revealed the beneficial effect of interlayer interactions for the design of heterogeneous electrocatalytic materials for water splitting.

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[1] D. Pan, T. Zhai, R. Zhang, Y. Yuan, H. Wang, and S. Lu, "Advancing layered double hydroxides (LDHs) as the anodes for efficient anion-exchange-membrane water electrolyzers," Nano Research, vol. 19, no. 1, p. 94907937, 2026, doi: 10.26599/NR.2025.94907937.

[2] U. Shamraiz, A. Majeed, B. Raza, N. u. Ain, and A. Badshah, "Exploring the potential of cobalt hydroxide and its derivatives as a cost-effective and abundant alternative to noble metal electrocatalysts in oxygen evolution reactions: a review," Sustainable Energy & Fuels, 10.1039/D3SE00942D vol. 8, no. 3, pp. 422-459, 2024, doi: 10.1039/D3SE00942D.

[3] H. Zhou et al., "Strategies to maximize the oxygen evolution reaction in layered double hydroxides by electronic defect engineering," eScience, vol. 5, no. 5, p. 100380, 2025/09/01/ 2025, doi: https://doi.org/10.1016/j.esci.2025.100380