Supplementary Information

The Performance of Nickel and Nickel-Iron Catalysts Evaluated As Anodes in Anion Exchange Membrane Water Electrolysis

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Target and Final Metal Loadings for the Anodes

As the electrodes for the AEMWE set up were made by hand-spraying a catalyst ink, there is always a certain amount of ink waste that occurs. Although that waste is accounted for in the ink formulation, the target electrode loading is not always obtained. Furthermore, the ink formulation was optimized for the Ir-black reference catalyst therefore the error on the Ni-based electrode loadings was higher, as shown in Table S1, where the intended metal loading is compared to the actual metal loading of each of the anodes.

Table S1: Anode Metal Loadings on the Membrane Electrode Assemblies

Catalyst	Intended Metal Loading [mg_{metal} cm^{-2}]	Actual Loading [mg_{metal} cm^{-2}]
Ir Black	3	2.9
Ni	6	3.5
$Ni_{90}Fe_{10}$	6	3.6
$Ni_{90}Fe_{10}/CeO_2$	6	5.3

Activity of CeO_2 towards OER

Figure S1 shows a cyclic voltammogram of the promotional effect that the ceria support has on the pure nickel nanoparticles.

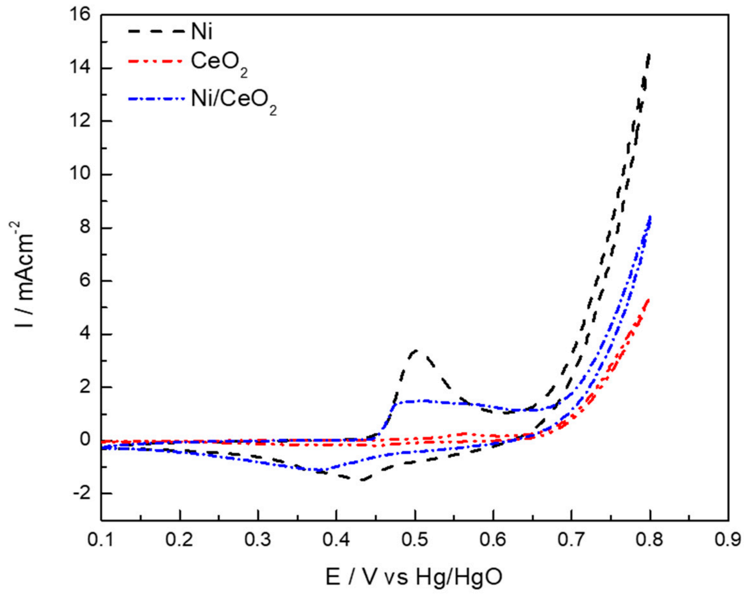


Figure S1: CVs from 0.1 to 0.8 V of Ni (black), CeO_2 (red) and Ni/CeO_2 (blue) run at 20 mV s^{-1} in 1 M KOH.

Reference Electrode Conversions

Conversions from the Hg/HgO to the RHE reference electrode are done with the following equation:

$$\boldsymbol{E_{RHE} = E_{Hg/HgO} + E^0_{Hg/HgO} + 0.0591(pH)} \qquad \textbf{Equation 1}$$

Based on the instrumentation specifications,

$$E^0_{Hg/HgO} = 0.098\ V$$

At pH 14,

$$\boldsymbol{E_{RHE} = E_{Hg/HgO} + 0.925} \qquad \textbf{Equation 2}$$

Using Equation 2, knowing $E^{water\ electrolysis}_{theoretical} = 1.23\ V\ vs\ RHE$,

$$E^{water\ electrolysis}_{theoretical} = 0.305\ V\ vs\ Hg/HgO\ at\ pH = 14$$

Similarly, at pH 13,

$$\boldsymbol{E_{RHE} = E_{Hg/HgO} + 0.866} \qquad \textbf{Equation 3}$$

Therefore,

$$E^{water\ electrolysis}_{theoretical} = 0.364\ V\ vs\ Hg/HgO\ at\ pH = 13$$

Characterization of the $Ni_{90}Fe_{10}/CeO_2$ Catalyst

As explained in the main article, there are two regions of the $Ni_{90}Fe_{10}/CeO_2$ sample. Figure S2a shows a TEM image of the cloudier region of the ceria supported sample, which corresponds mostly to the metal in the sample. Figure S2b shows a TEM image of the more structured area of the sample, which is mostly from the support.

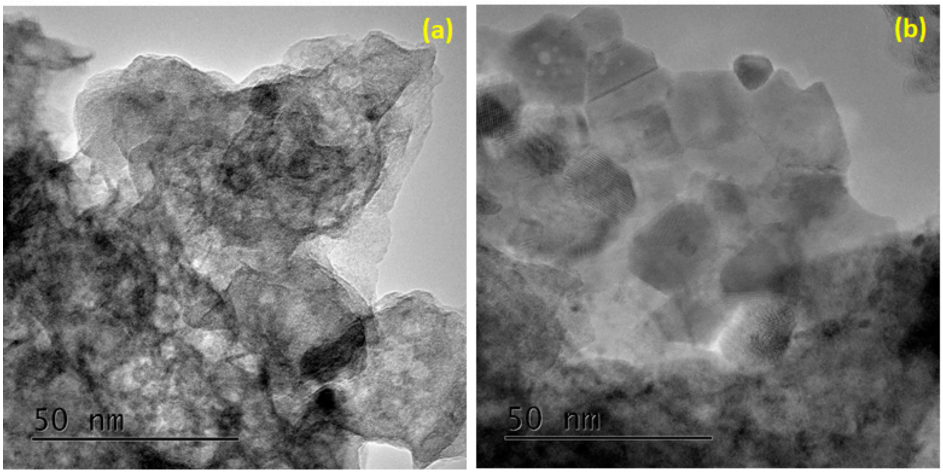


Figure S2: TEM Images of $Ni_{90}Fe_{10}/CeO_2$ Showing (a) Mostly the Ni and Fe and (b) Mostly the CeO_2 support.

Similarly, the STEM images shown in Figure S3 show a cloudier area (Figure S3a) as well as a more structured area (Figure S3b).

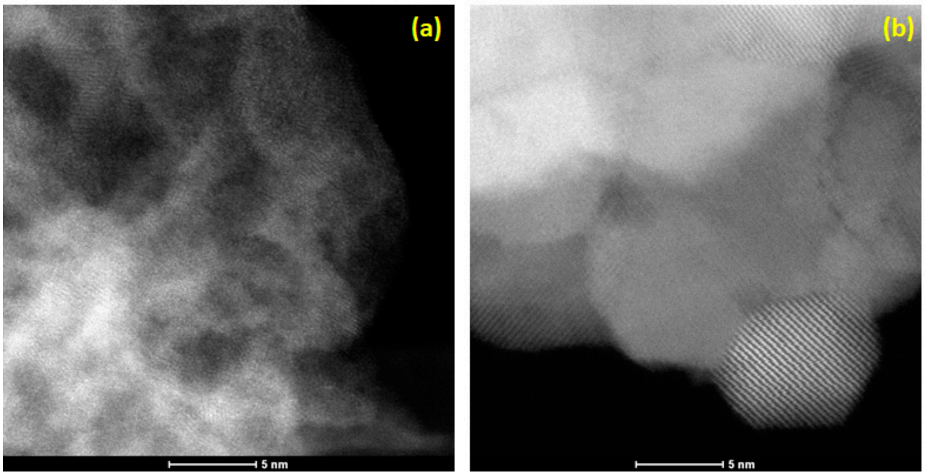


Figure S3: STEM Images of $Ni_{90}Fe_{10}/CeO_2$ Showing (a) Mostly the Ni and Fe and (b) Mostly the CeO_2 support.

The EDX spectrum below shows that the cloudier area of the STEM image shown in Figure S4a (Region 1) is mostly Ni and Fe, while the more structure area of the image (Region 2) is mostly the ceria support.

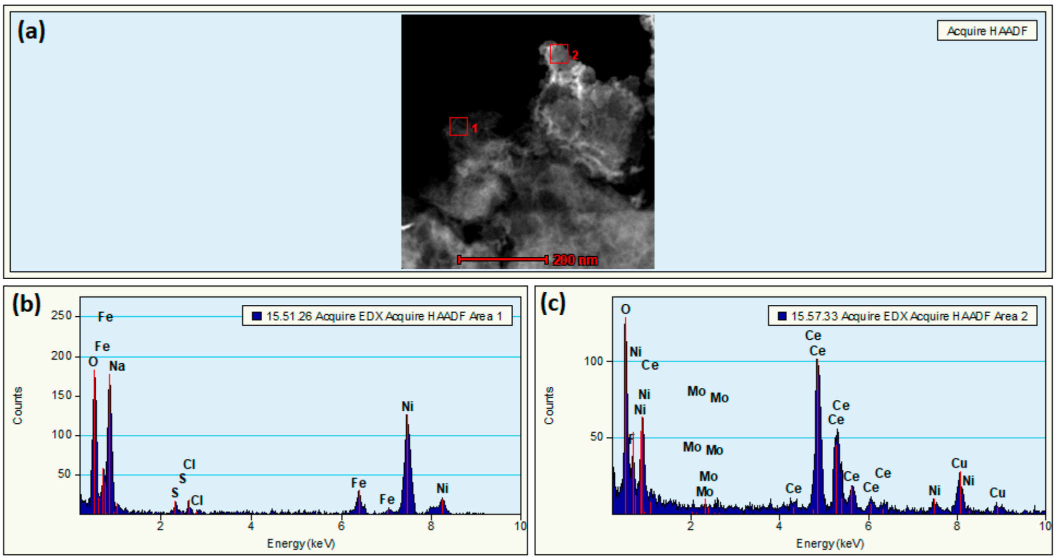


Figure S4: Spatially-Resolved EDX of $Ni_{90}Fe_{10}/CeO_2$. (a) Shows the two selected regions of the STEM image, (b) Shows the analysis of Region 1 and (c) Shows the analysis of Region 2.

Finally, Figure S5 shows the EDS mapping of the ceria-supported sample. Figure S5c shows, in orange, the region in which the mapping was carried out. As previously mentioned, the cloudier area to the left of the area delimited in orange, consist mainly of the Fe and Ni, as shown in Figures S5a and b, respectively. The more structured area on the right of the orange area can be attributed to the ceria support by looking at the lack of Ni and Fe on the right sides of Figures S5a and b. Due to issues with how the material was arranged and background subtraction, it was not possible to get a good mapping of the ceria support.

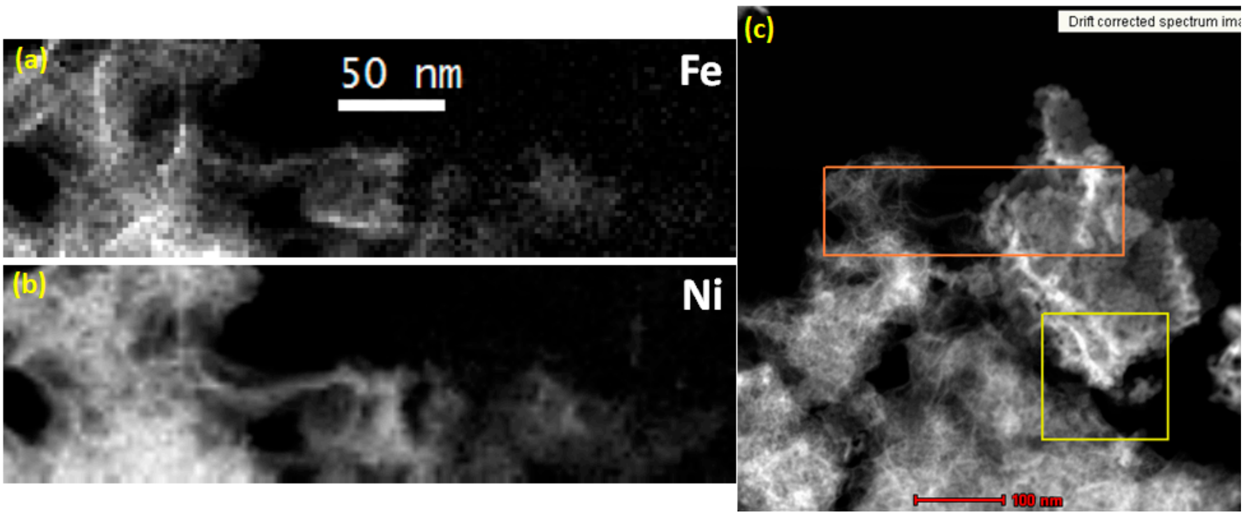


Figure S5: EELS Mapping of $Ni_{90}Fe_{10}/CeO_2$. (a) Shows the Fe mapping, (b) Shows the Ni mapping and (c) Shows the analyzed region in orange.

Cyclic Voltammogram Results Normalized by Mass of Metal for the Ni-based Catalysts

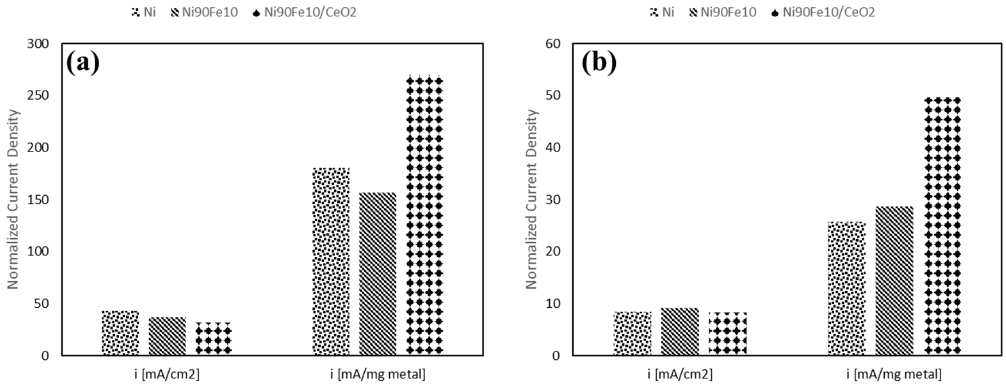
1. 

Figure S6: Comparison between Current Densities by Geometric Surface Area and by Mass of Metal at 0.8 V vs. Hg/HgO in (a) 1 M KOH and (b) 0.1 M KOH.