



## Supporting Information

# Optimization of Oxygen Evolution Reaction with Electroless Deposited Ni–P Catalytic Nanocoating

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### TOF calculation

The TOF is defined as the rate of production of oxygen molecules per available (and active) site:

$$\text{TOF} = j / 4nF$$

where  $j$  is the measured current density at a certain overpotential,  $F$  is the Faraday constant ( $96\,485\text{ C mol}^{-1}$ ) and  $n$  is the number of moles  $\times \text{cm}^{-2}$  of the available (active) sites determined considering all the total metal as active ( $\text{TOF}_{\text{tm}}$ ) or the amount of electrocatalysts participating in the OER by analysing the oxidation peak in the CV curves by the redox peak integration ( $\text{TOF}_{\text{redox}}$ ).

#### Calculation of $n$ for $\text{TOF}_{\text{tm}}$

Avogadro's number –  $6.022 \times 10^{23} \text{ at/mol}$

Atomic density of Ni–P ( $\text{at/cm}^2$ ) – determined by RBS spectra

$$n(\text{TOF}_{\text{tm}}) = \frac{\text{Atomic density of Ni-P (at/cm}^2\text{)}}{\text{Avogadro's number (at/mol)}} = n \text{ of Ni-P (mol/cm}^2\text{)}$$

#### Calculation of $n$ for $\text{TOF}_{\text{redox}}$

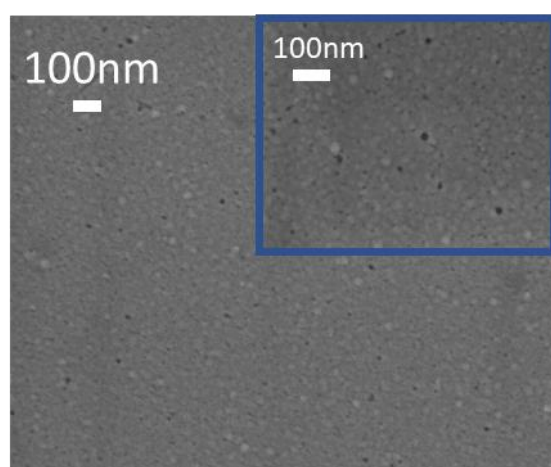
The amount of charge passed through the electrode during the redox reaction can be derived by integrating the redox peak in the cyclic voltammetry.

Thus, the  $n$  for  $\text{TOF}_{\text{redox}}$  can be calculated by the following expression:

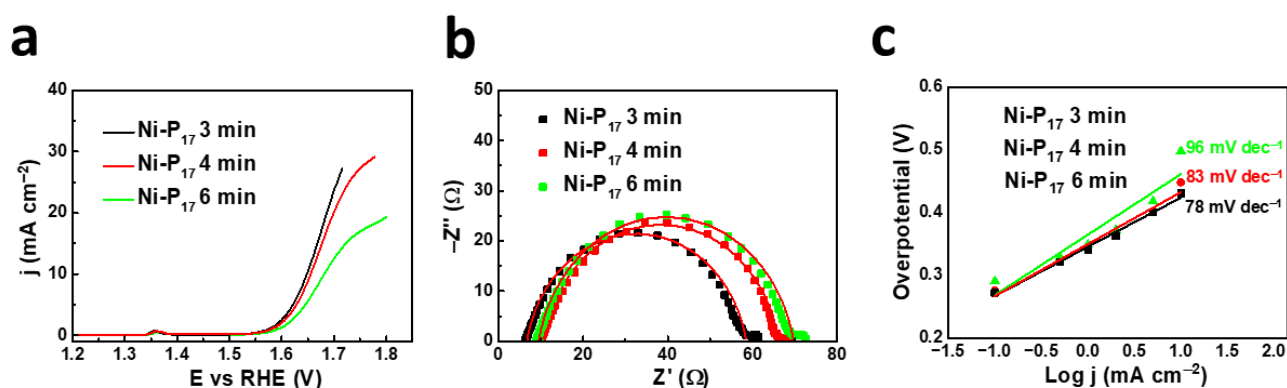
$$n(\text{TOF}_{\text{redox}}) = \frac{Q \text{ calculated from redox peak (C)}}{\text{Faraday constant } \left(96485 \frac{\text{C}}{\text{mol}}\right) \times \text{testing area of the electrode (cm}^2\text{)}} = n \text{ of Ni-P (mol/cm}^2\text{)}$$

### Calculation of $C_{dl}$ and ECSA

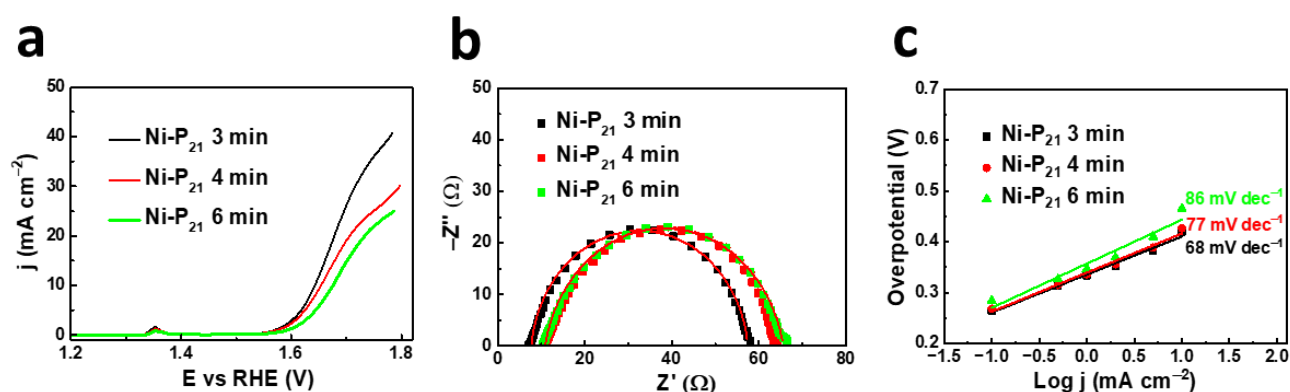
The double layer capacitance ( $C_{dl}$ ) was evaluated by cyclic voltammetry in non-Faradaic potential range 0.15–0.25 V vs Hg/Hg<sub>2</sub>Cl<sub>2</sub> at various scan rates (40, 60, 80, 100, 120, 140 mV s<sup>-1</sup>). Plotting the capacitive current density ( $|j_a - j_c|$ ) determined at 0.20 V vs. the scan rate ( $\nu$ ) yielded a straight line with a slope equal to twice the  $C_{dl}$ . The electrochemical active surface area is then calculated from the electrochemical double layer capacitance according to the expression [1]:  $ECSA = C_{dl}/C_s$ , where  $C_s$  is the specific capacitance of the material or the capacitance of an atomically smooth planar surface of the material per unit area under identical electrolyte conditions. Here, we adopt a general specific capacitance of 0.04 mF cm<sup>-2</sup>, typical value reported for a metal electrode in 1.0 M KOH solution [2].



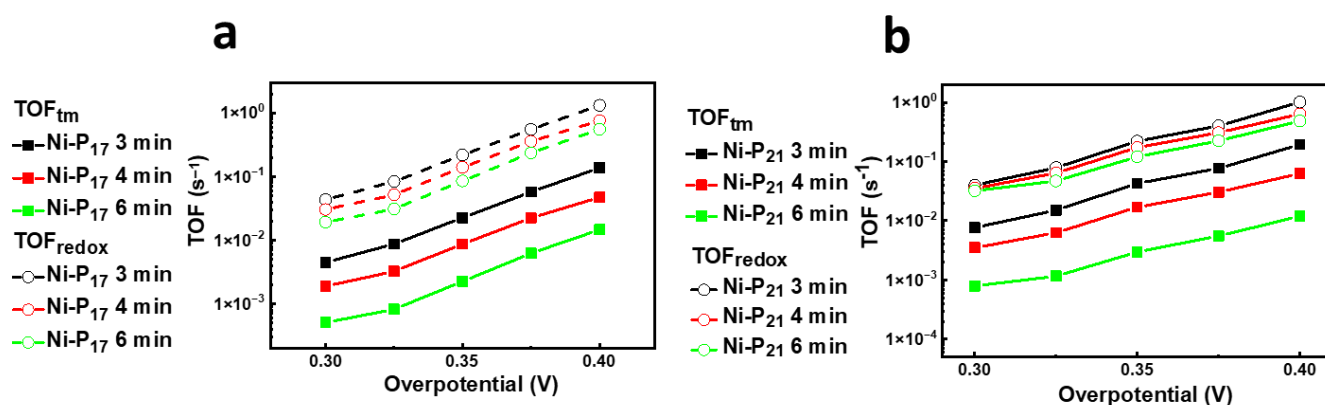
**Figure S1.** SEM micrograph after OER of Ni-P<sub>24</sub> coating deposited for 6 minutes.



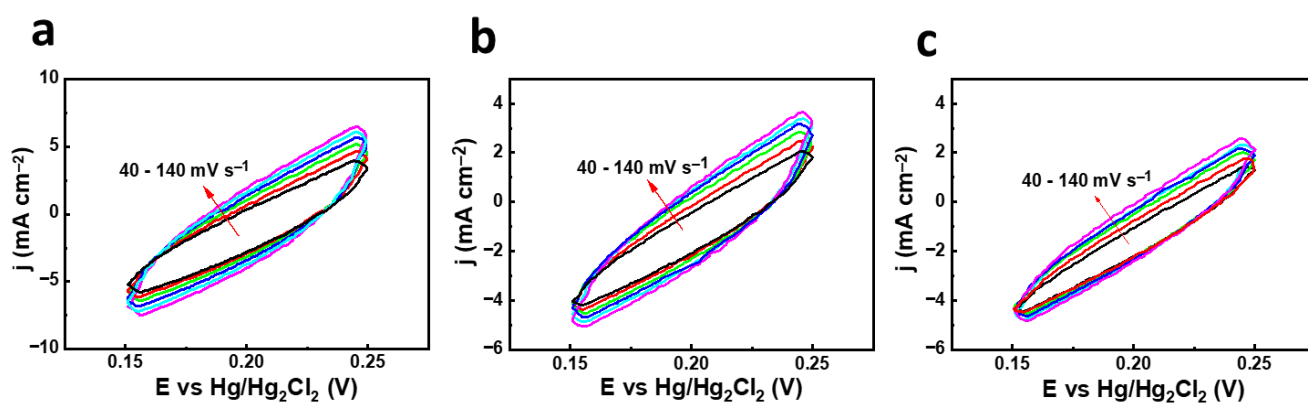
**Figure S2.** (a) Polarization curves, (b) Nyquist plots with the fitting curves plotted and (c) Tafel plots of Ni-P<sub>17</sub> coatings deposited at different times.



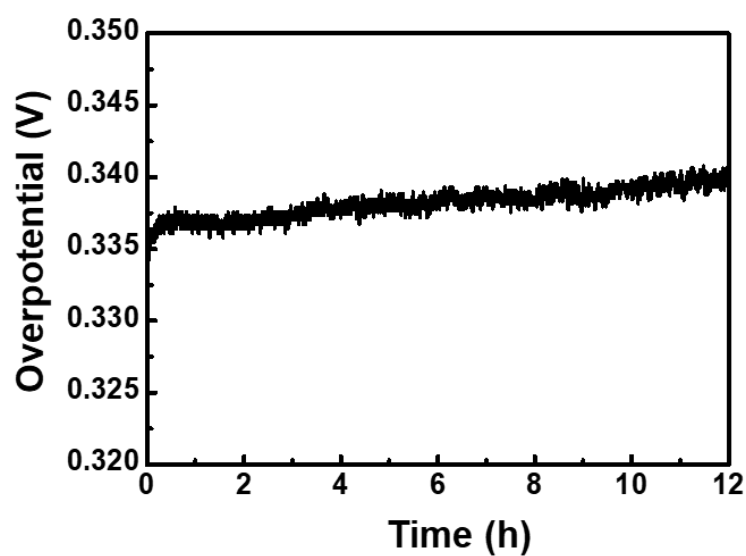
**Figure S3.** (a) Polarization curves, (b) Nyquist plots with the fitting curves plotted and (c) Tafel plots of Ni-P<sub>21</sub> coatings deposited at different times.



**Figure S4.** TOF<sub>tm</sub> and TOF<sub>redox</sub> of (a) Ni-P<sub>17</sub> and (b) Ni-P<sub>21</sub> samples deposited at different growth times.



**Figure S5.** Cyclic voltammograms in the region of 0.15-0.25 V vs. Hg/Hg<sub>2</sub>Cl<sub>2</sub> with different potential scanning rates of Ni-P<sub>24</sub> coatings deposited on Ni foam for (a) 3, (b) 4 and (c) 6 minutes.



**Figure S6.** Chronopotentiometric response of Ni-P<sub>24</sub> sample deposited for 3 minutes on nickel foam held at 10 mA cm<sup>-2</sup> for 12h.

#### References

1. McCrory, C.C.L.; Jung, S.; Ferrer, I.M.; Chatman, S.M.; Peters, J.C.; Jaramillo, T.F. Benchmarking hydrogen evolving reaction and oxygen evolving reaction electrocatalysts for solar water splitting devices. *J. Am. Chem. Soc.* **2015**, *137*, 4347–4357.
2. Ahmed, A.T.A.; Hou, B.; Chavan, H.S.; Jo, Y.; Cho, S.; Kim, J.; Pawar, S.M.; Cha, S.; Inamdar, A.I.; Kim, H.; Im, H. Self-assembled nanostructured CuCo<sub>2</sub>O<sub>4</sub> for electrochemical energy storage and the oxygen evolution reaction via morphology engineering. *Small* **2018**, *14*, 1800742.