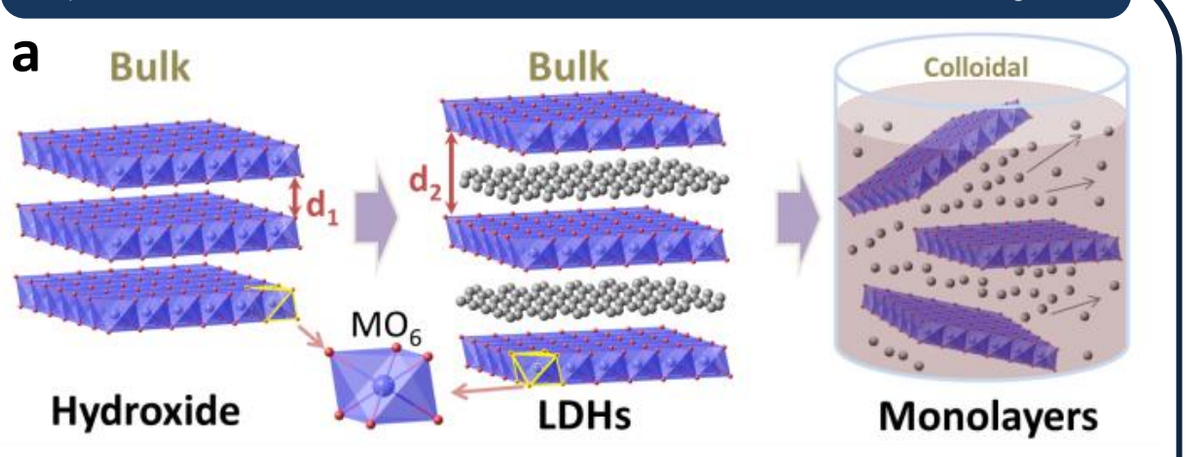
2017 International Bionic Innovation Competition

Compete with PSII-WOC: Earth-Abundant Electrocatalysts for Water Oxidation

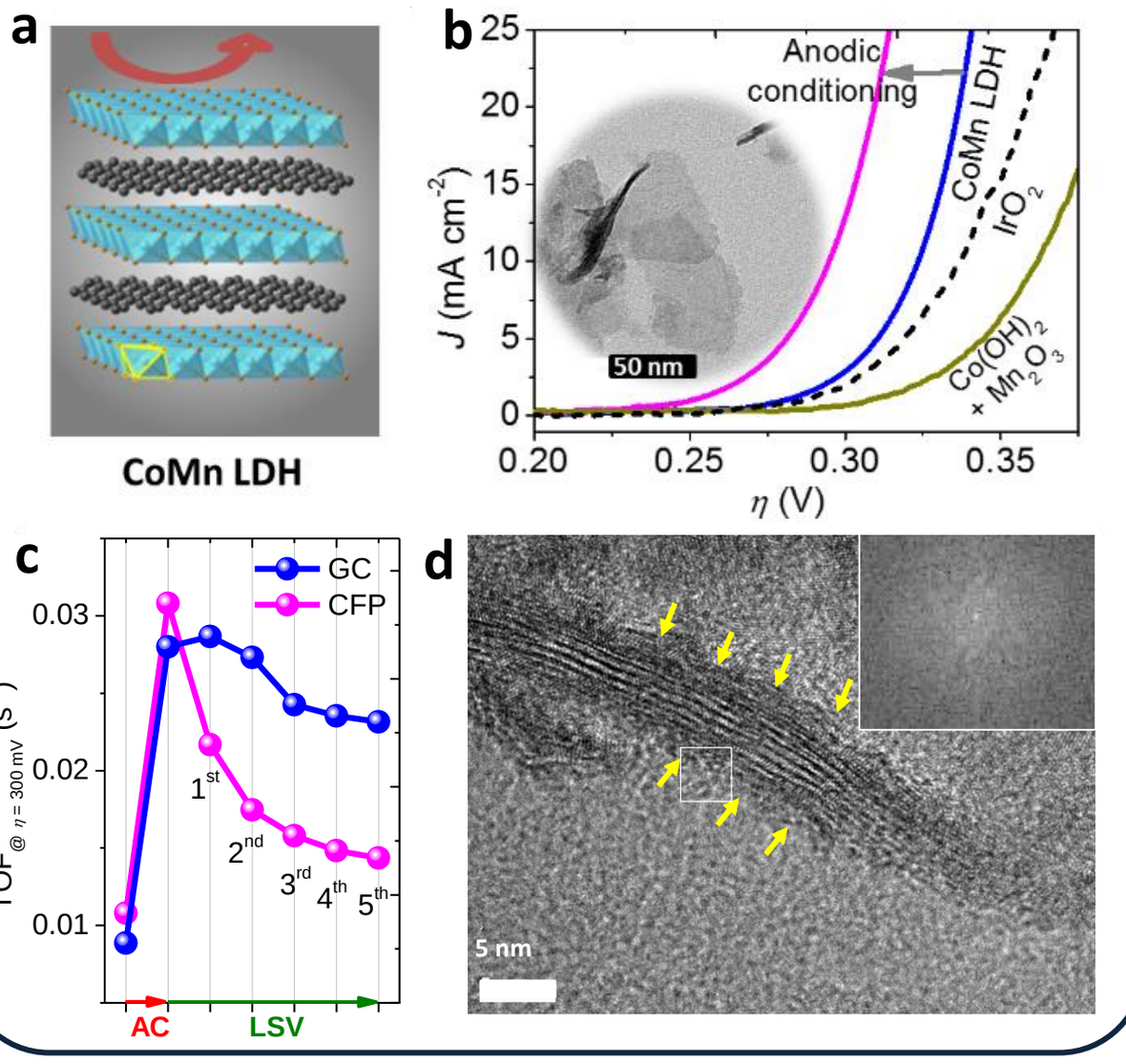
Natural photosystem II water-oxidizing complex (PSII-WOC) is still the most efficient system to use solar energy to oxidize water ($4H_2O \rightarrow O_2 + 4H^+ + 4e^-$). The development of efficient, abundant and inexpensive oxygen evolution reaction (OER) catalysts to replace PSII-WOC is one of the main themes of current research in renewable energies. Herein we show that

1) Liquid exfoliation is an effective method to improve the activity of catalysts without alternating the compositions or structures of layered double hydroxides (LDHs).
2) Ultrathin nanoplates of CoMn LDH is a highly active and stable oxygen evolution catalyst and it can be easily synthesized via a one-pot co-precipitation method.
3) A simple electrochemical etching method was developed to produce hierarchical nanoporous CoO_x particles, resulting in a highly active OER catalyst.
4) CoP and Ni_2P were highly active for not only HER (hydrogen evolution reaction) but also OER, which enable the full water splitting devices using only one catalyst.
5) Metal selenides are unstable and entirely converted into metal hydroxides under OER conditions. Inspired by this knowledge, nanostructured $Ni_xFe_{1-x}Se_2$, a hitherto unknown metal selenide, was synthesized and was used as a templating precursor to obtain highly active nickel iron oxide catalysts.

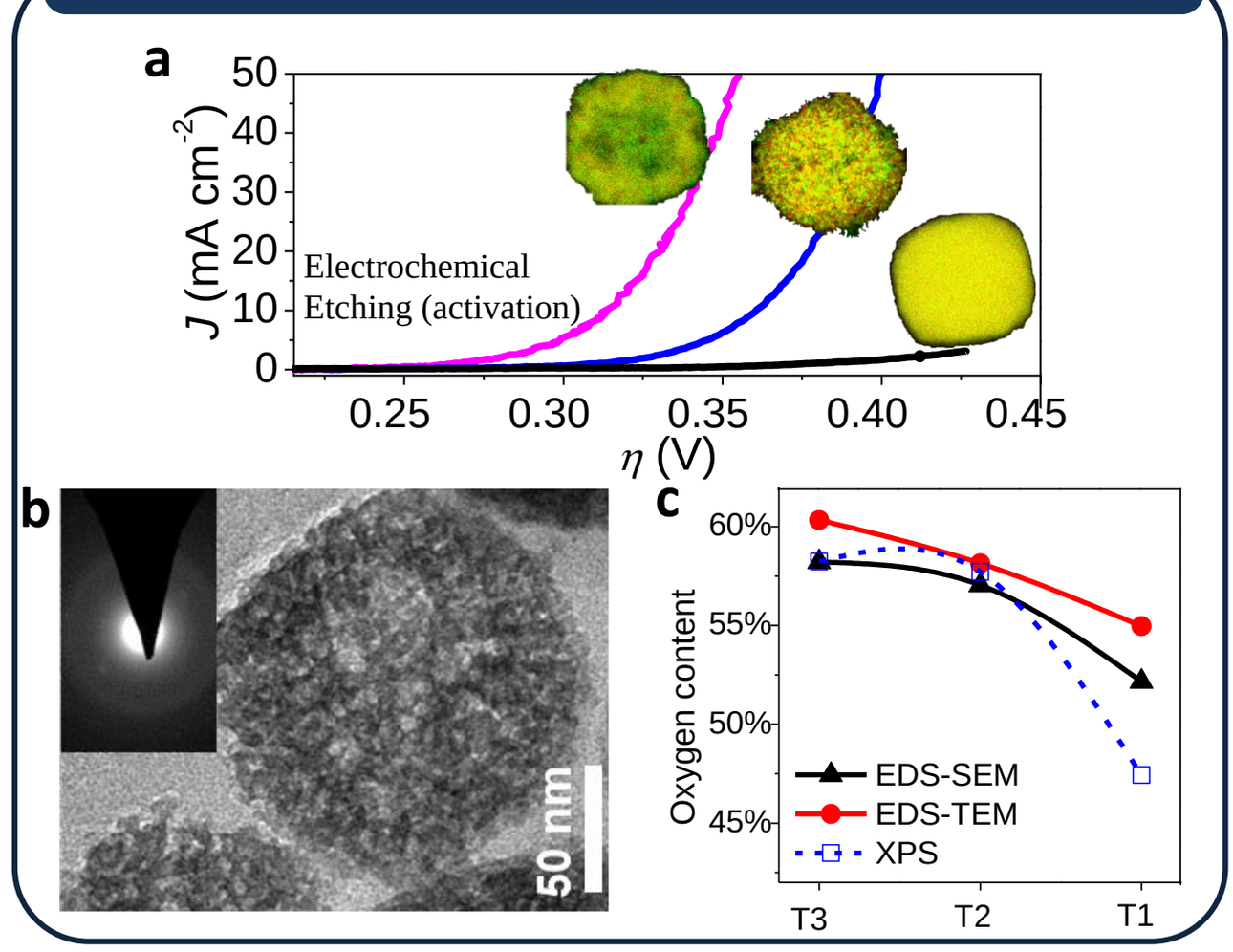
1) Exfoliation of LDHs for Enhanced OER Catalysis



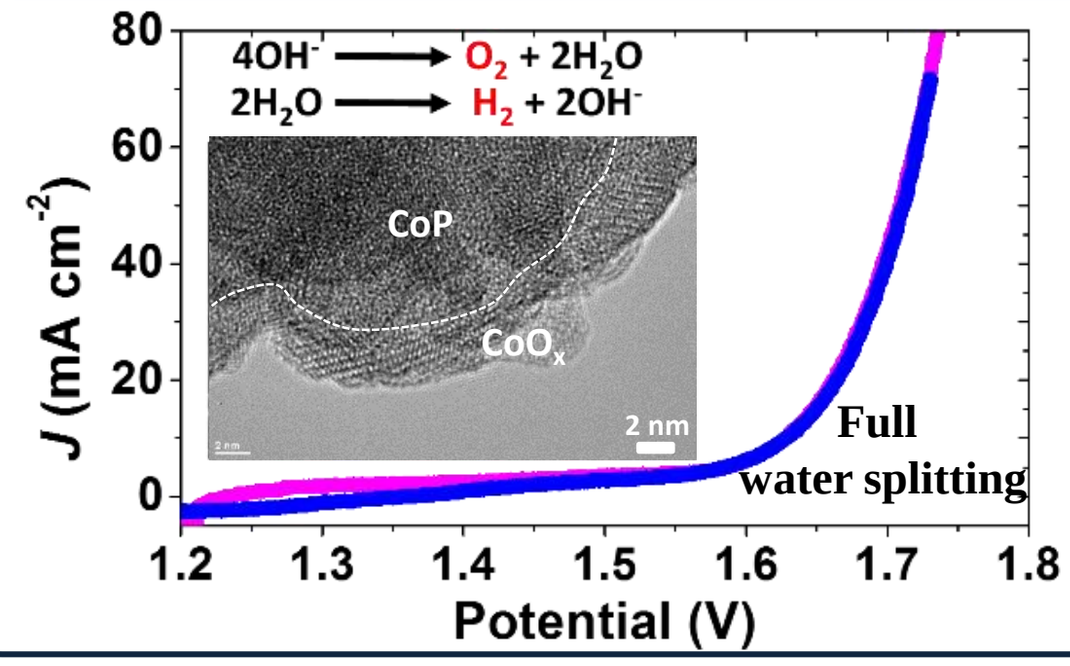
2) Ultrathin CoMn LDH - An Efficient OER Catalyst



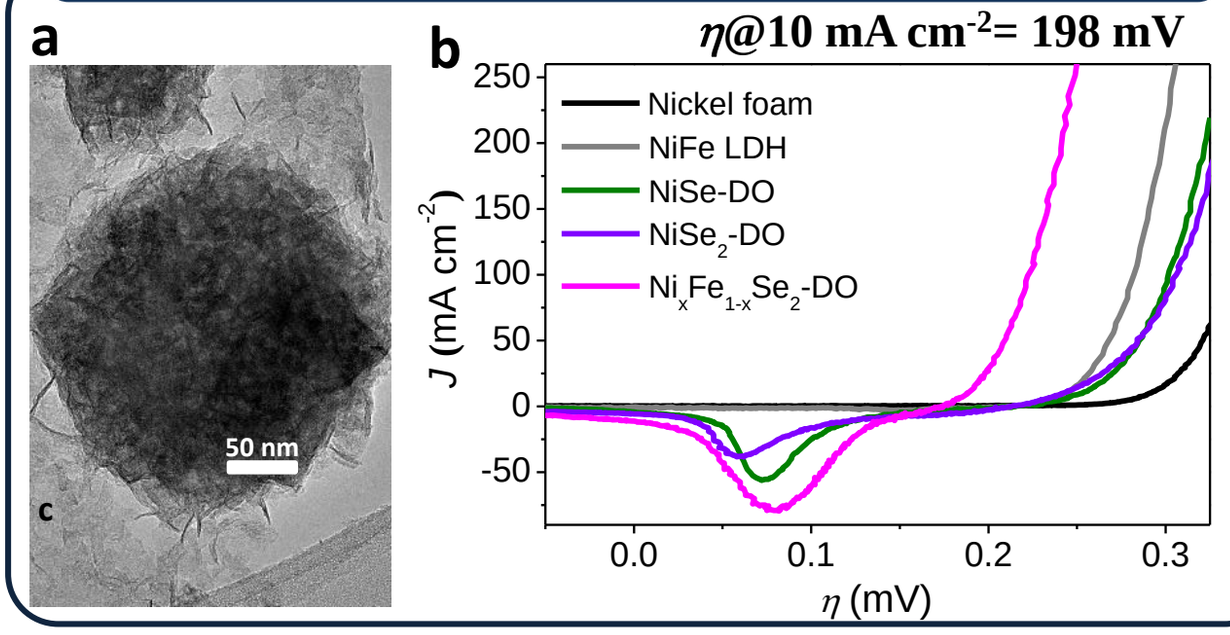
3) Nanoporous OER Catalyst by Electrochemical Etching



4) Bifunctional Water Splitting Catalysts - CoP & Ni_2P



5) A $Ni_xFe_{1-x}Se_2$-Derived Efficient OER Catalyst



Publications/patents or Rewards

1) Exfoliation of layered double hydroxides for enhanced oxygen evolution catalysis. ***Nat. Commun.*** 2014, 5, 4477. Highly Cited Paper (ISI Essential Science Indicators)
2) Ultrathin cobalt–manganese layered double hydroxide is an efficient oxygen evolution catalyst. ***J. Am. Chem. Soc.*** 2014, 136 (47), 16481-16484. Highly Cited Paper
3) Ni_2P as a Janus catalyst for water splitting: The oxygen evolution activity of Ni_2P nanoparticles. ***Energy Environ. Sci.*** 2015, 8 (8), 2347. Highly Cited Paper
4) A nanoporous oxygen evolution catalyst synthesized by selective electrochemical etching of perovskite hydroxide $CoSn(OH)_6$ nanocubes. ***Energy Environ. Sci.*** 2016, 9, 473.
5) A nickel iron diselenide-derived efficient oxygen-evolution catalyst. ***Nat. Commun.*** 2016, 7, 12324.
6) Efficient water splitting catalyzed by cobalt phosphide-based nanoneedle arrays supported on carbon cloth. ***ChemSusChem*** 2016, 9, 472. Highly Cited Paper
7) An easily-accessed nickel nanoparticle catalyst for alkene hydrosilylation with tertiary silanes. ***Angew. Chem. Int. Ed.*** 2016, 128, 12483.
8) From water oxidation to reduction: transformation from $Ni_xCo_{3-x}O_4$ nanowires to NiCo/NiCoOx heterostructures. ***ACS Appl. Mater. Interface*** 2016, 8, 3208.
9) Method of synthesis of oxygen evolution reaction catalyst, **European Patent**, PCT/EP2016/16189000.9.
10) New catalysts for oxygen evolution reaction, **European Patent**, PCT/EP2016/16180605.4.
11) **Clariant CleanTech Award Switzerland**, Oct. 2016