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Cobalt-based catalysts for bifunctional electrochemistry: ORR/OER and HER/OER

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Electrocatalysis is critical to numerous renewable energy technologies, such as fuel cells, metal-air batteries and electrolyzers. These devices require electrocatalysts for reactions such as the oxygen reduction reaction (ORR), oxygen evolution reaction (OER) and/or the hydrogen evolution reaction (HER) – which are multi-step, multi-electron electrochemical reactions that generally have high overpotentials and slow kinetics. While effective catalysts for these reactions are known and are commercially available, most of them are based on precious metals and hence are not economically viable for widespread application. Additionally, many of these catalysts still suffer from reaction poisoning and poor electrocatalytic selectivity and stability, further decreasing their overall utility. An ideal catalyst would be easily prepared, stable, and cost effective, and preferably exhibit bifunctional behavior, as such catalysts could simplify design protocols for rechargeable metal-air batteries and regenerative fuel cells/electrolyzers and lead to the realization of efficient and practical devices.

With this in mind, we have recently prepared cobalt oxide- and cobalt phosphide-based nanostructured films through simple electro-deposition and annealing/reaction processes.[1,2] Nanostructured cobalt oxide-based catalysts exhibit excellent performance for both the ORR and OER in alkaline electrolyte, on par with if not better than commercial catalysts, such as 20% Pt/C and 20% Ir/C.[1] Similar cobalt phosphide-based thin films also compare favorably to such commercial benchmarks when examined as HER–OER catalysts.[2] As a demonstration of this bifunctional nature, water electrolysis with cobalt phosphide-based electrocatalysts at both the anode and cathode is demonstrated. To date, the observed cell overpotential is among the lowest of the few reported cobalt-based symmetrical electrolysis cells. This presentation will highlight various aspects of this work – including the synthetic approach to these materials and the detailed electrochemical studies. Given that cobalt is currently about 1,500 times cheaper than platinum, these catalysts offer promise for widespread next-generation renewal energy technologies.

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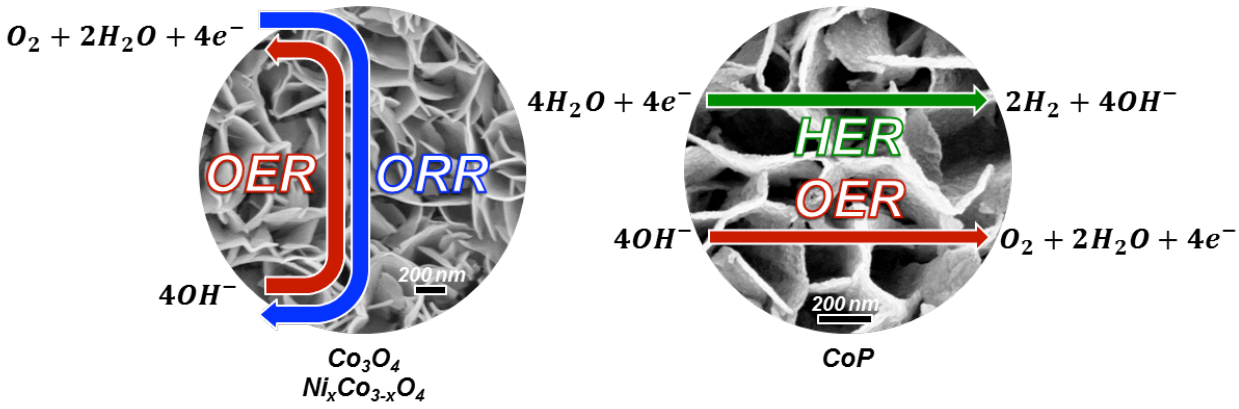

Fig1. Schematic of ORR/OER or HER/OER bifunctional behaviour with cobalt-based nanostructured films.

1. T. N. Lambert, J. A. Vigil, S. White, D. J. Davis, S. J. Limmer, P. D. Burton, E. N. Coker, T. E. Beechem and M. T. Brumbach *Chem. Commun.* **2015**, *51*, 9511-9514.
2. J. A. Vigil and T. N. Lambert *R. Soc. Chem. Adv.* **2015**, *5*, 105814-105819.

Presentation Method (Invited Oral 20 minutes):