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Development of a novel bipolar stacked Iron/Air Battery Stack

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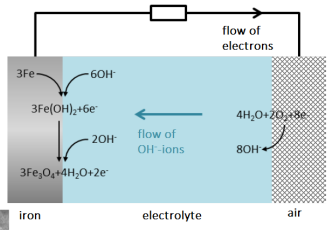
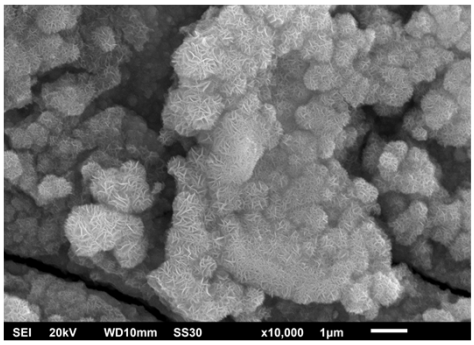
MOTIVATION

Electrical energy from renewable sources needs to be buffered due to high fluctuations. The iron/air battery is a promising system for this application. Iron is a cheap, abundant, and environmentally safe material. The theoretical energy density of this system is about six times higher compared to state of the art Li-Ion technology [1,2].

IRON ELECTRODE

- Traditional Iron electrodes are hot pressed and have a low coulombic efficiency
- Goal: electrochemical prepared iron electrodes and CE >80 % with electrode and electrolyte additives
- Current state: high capacities ≈ 1000 mhAg^{-1}
- Synthesis of hybrid Fe-Bi-S-Electrodes

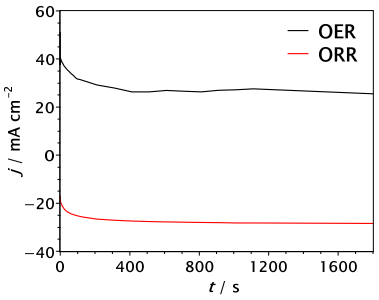




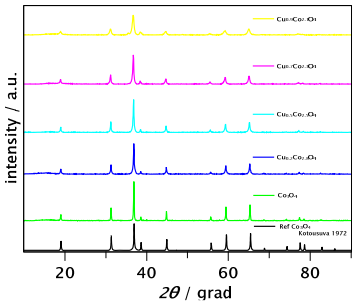
SEM Image of Fe-Bi-hybrid

AIR ELECTRODE

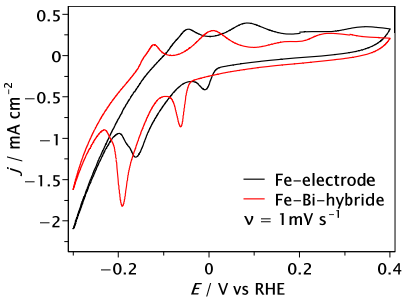
- Air Electrodes are carbon based and utilize noble metal catalyst materials
- Carbon corrodes at low voltages (~0.8 V) and is not applicable [3]
- Goal: Carbon and noble metal free air electrode. Transition metal oxides with spinel structure (especially Co_3O_4) show high bifunctional activity [4]



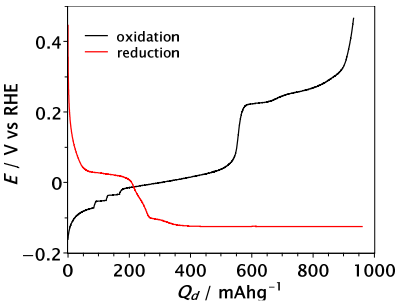
Chronoamperometry of air electrode with commercial Co_3O_4 catalyst at 0.3 and 1.8V in 1 M KOH @ 100 mlmin^{-1} air flow



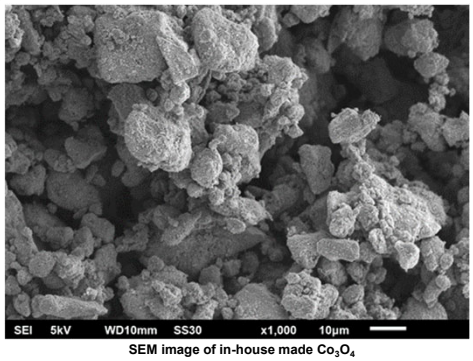
XRD data of copper substituted Co_3O_4



Comparison Fe- and Fe-Bi-hybrid electrode pH = 14.9



Fe electrode reduction & oxidation curve pH = 14.9 @ C/4



SEM image of in-house made Co_3O_4

CONCLUSION AND OUTLOOK

- ✓ High capacity iron electrodes have been produced
- ✓ Fe-Bi Hybrid electrode successfully produced
- ➢ Enhancing cyclic stability by improving morphology
- ➢ Increasing coulomb efficiency by using additives
- ➢ 10 cell battery stack with high capacity and high cycle stability
- ➢ Bipolar design consisting of polymer/carbon based bipolar plates
- ✓ Air electrodes with high initial current densities and commercial Co_3O_4 catalyst have been produced
- ➢ Study the dependence of element substitution and synthesis route of Co_3O_4 and other spinel structures on electro-catalytic activity
- ➢ Air electrodes with improved, in-house made, catalyst
- ➢ Parameter study to find optimum material composition and process parameters

References
[1] Tarascon J-M, Armand M (2001) Issues and challenges facing rechargeable lithium batteries. Nature 414(6861):359–367
[2] Y. Li and J. Lu, "Metal–Air Batteries: Will They Be the Future Electrochemical Energy Storage Device of Choice?," ACS Energy Letters, vol. 2, no. 6, pp. 1370–1377, 2017, doi: 10.1021/acsenergylett.7b00119.
[3] T. R. Crompton, Battery reference book, 3rd ed. Oxford: Newnes, 2007.
[4] D. Wittmaier *et al.*, Bifunctional, Carbon-Free Nickel/Cobalt-Oxide Cathodes for Lithium-Air Batteries with an Aqueous Alkaline Electrolyte, Electrochimica Acta, vol. 149, pp. 355-363, 2014