Reduced Graphene Oxide Supported Transition Metal Oxide Electrocatalysts for Zinc-Air and Zinc-Air Flow Batteries

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Due to the high abundance of zinc and non-flammable aqueous electrolyte, zinc-air batteries (ZABs) are an economical and safe grid-scale energy storage solution for renewable energy generation plants situated in remote locations. Efficiency of metal-air batteries are limited by the overpotentials of the oxygen reduction reaction (ORR) and oxygen evolution reaction (OER), for which noble metals such as Pt and IrO_2 are benchmark electrocatalysts.[1] Transition metal oxides (TMOs) are being studied as possible substitutes for scarce and expensive noble metals.[2] In our recent work, bimetallic TMOs based on Fe/Co and Co/Ni are finely dispersed on reduced graphene oxide to achieve high catalyst activation for high current density operations of zinc-air batteries.

Bimetallic oxides (Fe/Co and Ni/Co) in various ratios were synthesized by dispersing their respective nitrate precursors and graphene oxide (GO) in water, drying the suspension, and calcining the residue at 350°C for 4 h. Upon heat treatment, GO partially loses oxygen functional groups to form electrically conductive rGO. The remaining oxygen functional groups on rGO were found to homogeneously disperse the metal oxides across the surface of the rGO particle which greatly activated the metal oxide for electrocatalytic reactions.

The FeCo-rGO and NiCo-rGO catalysts were loaded on nickel foam and assembled into the air cathodes of ZABs. Hybridization with rGO was found to be key in activating the catalysts for practical ZAB operations at high current density of 100 $mA \cdot cm^{-2}$ despite showing similar performance in electrochemical tests which are typically carried out at low current densities (<1 $mA \cdot cm^{-2}$). Similar trends were also found for NiCo-rGO. Possible industrial application was demonstrated with the application of rGO supported Fe/Co catalysts in a zinc-air flow battery.

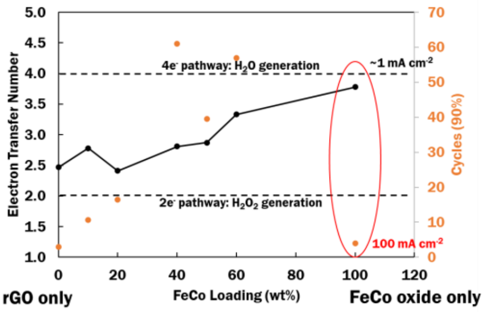

Figure 1. Inadequacy of electrochemical test results in predicting battery cyclability at high current density operations (100 $mA \cdot cm^{-2}$). Fe/Co loading on rGO is varied from 0 to 100 wt%. Solid line: Electron Transfer Number calculated from electrochemical test. Orange dots: Battery cycles assessed at 90% current capacity.

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