Diagnosing the operation and degradation mechanisms in cathodes for rechargeable aqueous zinc batteries

Our transition to a decarbonised energy economy continues to demand new technologies to address the challenge of how we store energy. Major developments have been made in scaling the performance of rechargeable Li-ion batteries, all while making them more affordable, with the dividends now realised in a blossoming electric car industry. However, the need for energy storage at the electric grid level is forecast to continue to grow rapidly, driven by the intermittency of renewables, where the high energy density yet high cost of Li-ion is not necessarily best suited.

There has been a recent revitalisation of interest in the rechargeable Zn-ion battery in order to address this demand for an energy storage technology dedicated to stationary applications. Zn-ion offers significant advantages in terms of cost, recycling, supply chain security, and safety, all while still providing competitive energy density and lifespan.[1]

Challenges remain however, including the problems of dendrite formation and corrosion at the metal anode,[2] and unwanted reactions at the cathode. This project will focus on understanding these reactions at the cathode, nanostructured MnO_2, and developing tailored electrolytes to suppress them. Achieving this goal will require diagnosing a set of intertwined parameters, including the structure of the cathode material and its interface, the changing pH of the electrolyte, the Zn-ion salvation structure, and others, many of which will evolve while the battery is cycled. Fortunately, at Warwick you will have access to one of the UK's best equipped materials characterisation facilities, and will use a suite of advanced techniques to disentangle what leads to performance loss in Zn-ion cathodes. Operando X-ray absorption spectroscopy will grant insights into solvation structure and chemical reactions, in-situ X-ray diffraction and transmission electron microscopy will tell us about the structure changes, and nuclear magnetic resonance will inform us about the local pH and interfacial byproducts.

This project is suited to students with an interest and background spanning the broad remit of materials chemistry; including physics, chemistry, and materials science, and enjoys learning and mastering sophisticated experimental techniques. If you are interested in this project please contact me at alex.w.robertson@warwick.ac.uk.

1. *Zinc-ion batteries for stationary energy storage*. D. Higgins et al. *Joule* (2023). DOI: 10.1016/j.joule.2023.06.007
2. Decoupling, quantifying, and restoring aging induced Zn-anode losses in rechargeable aqueous zinc batteries. A. W. Robertson et al. *Joule* (2023). DOI: 10.1016/j.joule.2023.01.010