Diagnosing cathode mechanisms and degradation in aqueous batteries

Aqueous batteries offer a promising route towards safe, sustainable, and cost-effective energy storage, particularly for large-scale and long-duration applications. However, the commercial deployment of these technologies is limited by an incomplete understanding of the processes occurring within their oxide cathodes. Charge storage may involve intercalation, structural transformations, dissolution and reprecipitation, while repeated cycling can produce irreversible phase changes and loss of active material.

This PhD project will investigate these coupled charge-storage and degradation mechanisms using advanced structural and imaging techniques. By combining a suite of advanced characterisation techniques, including operando transmission electron microscopy, X-ray diffraction, and neutron diffraction, the project will connect nanoscale transformations with changes in the bulk crystal structure during battery operation. The resulting mechanistic understanding will inform design principles for better aqueous battery cathodes.

As a student on this project, you will work with battery scientists in the Physics Department and Warwick's WMG to apply these advanced characterisation approaches. If the idea of applying sophisticated experimental approaches to attain a better understanding of a complex but important materials problem appeals, then this PhD project could be for you.

Due to its interdisciplinary nature, this project should be eligible for the **fully funded UK and international Interdisciplinary Chancellors** scholarship.

You will join a team of materials scientists who use advanced characterisation techniques to understand new energy and nanomaterials. This project is ideally suited to a student with a background and interest in physics, chemistry, materials science, and related subjects. If you are interested contact me at alex.w.robertson@warwick.ac.uk.

Below are some relevant publications from the scientists you would work with on the project:

1. Yi Yuan, *et al.* **Identifying the role of Zn self-dissolution in the anode corrosion process in Zn-ion batteries**. *Energy Environ. Sci.* 2025; 18 (11): 5610–5621. doi: 10.1039/d5ee00485c
2. Zixuan Li, *et al.* **Cation-disordered rocksalt cathode for anode-free zinc-ion batteries.** *Energy Environ. Sci.* 2025; 18 (23): 10135–10146. doi: 0.1039/d5ee02643a
3. Yi Yuan, *et al*. **Diagnosing the Electrostatic Shielding Mechanism for Dendrite Suppression in Aqueous Zinc Batteries**. *Adv Mater*. 2024; 36(9): e2307708. doi: 10.1002/adma.202307708
4. Ashok S Menon *et al*. **Advancing Battery Diagnostics through *Operando* Neutron Diffraction of Unmodified Nondeuterated Li-Ion Single-Layer Pouch Cells**. *Chem. Mater.* 2026; 38 (9): 4517–4527. doi: 10.1021/acs.chemmater.5c03201
5. Ashok S. Menon, *et al.* **Spatially resolved *operando* X-ray diffraction for mapping heterogeneities in Li-ion single-layer pouch cells**. *Chem. Commun.* 2025; 61 (83): 16226–16229. doi: 10.1039/d5cc02935j