Constructing an Artificial Interphase for Tin Metal Anodes through Informed Design

Tin metal anodes have recently emerged as promising candidates for next-generation aqueous batteries due to their high theoretical capacity and cost-effectiveness.[1] However, their practical deployment is hindered by interfacial instability, leading to uncontrolled deposition/dissolution, corrosion, and formation of unwanted byproducts.[2] We want to design and construct an ideal interphase that stabilizes Sn metal anodes, enabling improved cycling performance and durability, but for that we first need a comprehensive understanding of the interface between electrode and electrolyte, and how it changes as the rechargeable battery is cycled.

The electrolyte–electrode interface plays a critical role in governing Sn behaviour during electrochemical cycling. A well-engineered interphase can:

- Regulate Sn deposition/dissolution kinetics
- Suppress parasitic reactions and surface passivation
- Mitigate corrosion under aqueous conditions

Despite its importance, the nature of the interphase formed on Sn in aqueous systems remains poorly understood. This project will bridge this knowledge gap by correlating interphase composition and structure with cycling performance and the anode's durability.

To tackle this challenge, you will employ advanced characterisation techniques available at Warwick, including:

- Operando electrochemical liquid-cell TEM for real-time visualization of Sn deposition/dissolution.[3]
- Cross-sectional TEM to resolve interphase morphology and structure.
- XPS and XAS for surface composition and solvation analysis.
- Mass spectrometry to quantify interphase components and unwanted byproducts.

These will allow you unprecedented access to information at the interface, which will provide you the basis to consider how to appropriately tailor your battery to achieve the best performance.

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.

1. A high-capacity Sn metal anode for aqueous acidic batteries. H. Zhang, Y. S. Meng, et al. *Joule*, **7**, p971-985 (2023). https://doi.org/10.1016/j.joule.2023.04.011
2. Recent Advances in Metallic Tin Anodes: An Emerging Field of Rechargeable Aqueous Batteries. X. Lan, X. Liu, C. C. Li, et al. *ACS Applied Materials & Interfaces*, **17**, p24763-24777 (2025). https://doi.org/10.1021/acsami.5c01275
3. Identifying the role of Zn self-dissolution in the anode corrosion process in Zn-ion batteries. Y. Yuan, A. W. Robertson, et al. *Energy & Environmental Science*, **18**, p5610-5621 (2025). https://doi.org/10.1039/D5EE00485C