Constructing an artificial interphase for zinc metal anodes through informed design

A longstanding challenge in rechargeable batteries has been to attain a practical metal anode, allowing for optimal energy densities and a good voltage window. But unfortunately the inherent reactivity of many battery chemistries, like lithium ion, mean that metal anodes would undergo prohibitive degradation. This is why modern Li-ion batteries use graphite as an anode host. The aqueous zinc battery has (re-)emerged as a prime candidate for realising the advantages of using a metal anode, as its relatively low reactivity bypasses some of the most serious problems with metals like lithium, with it even able to operate with a water-based electrolyte. Yet even these anodes still suffer from failures due to dendrite growth and hydrogen evolution.

Looking to the abundant research done on the lithium metal anode presents a potential solution; crafting a solid-electrolyte interphase (SEI) layer that coats the zinc anode in a protective skin, and thus limiting dendrite detachment and preventing side reactions while still permitting Zn ion cycling through it. We can achieve this by tailoring the electrolyte with the suitable inclusion of additives and co-solvents, and thus engineering an SEI layer with optimal properties. Rather than doing this by trial-and-error, we instead want to do this by developing a fundamental understanding of the interlinking factors that lead to both; (i) the formation of a particular SEI, and (ii) which SEI enables good cycling performance. This requires a comprehensive application of a broad suite of experimental characterisation techniques.

In this project, you will intentionally engineer interphase layers to achieve robust Zn metal anodes for rechargeable batteries. By combining advanced characterisation techniques, including transmission electron microscopy (TEM), mass spectrometry, X-ray absorption spectroscopy (XAS), mechanical indentation, and other methods, you will reveal the interlinking structural, chemical, and physical properties that enable a high performance zinc metal anode that is robust to repeated recharge cycles, and then use this knowledge to craft the ideal artificial SEI layer. You will get the opportunity to learn several sophisticated experimental techniques due to the extensive world-leading materials characterisation infrastructure available at Warwick University, and be able to collaborate with scientists at Oxford University and internationally.

This project is ideally suited to a student with a background and interest in the materials sciences, including physics, chemistry, materials science, chemical engineering, and related subjects. If you are interested contact me at alex.w.robertson@warwick.ac.uk.