

Understanding the ageing mechanism of batteries to improve cycle life at high temperature

Echion Technologies Ltd, a battery technology spinout company from the University of Cambridge, used neutron diffraction and mass spectrometry to achieve greater insight into battery cycle life and help improve performance and material endurance.

Challenge

Echion are a leading light in battery technology worldwide as their anode materials deliver an exceptionally long cycle life, superfast charging capability, and outstanding safety. Echion has developed a range of patented anode materials based on mixed niobium oxides, with applications in fast-charging lithium-ion batteries, where they achieve an excellent cycle life at 25°C, with the ability to perform thousands of cycles. For Li-ion batteries, the cell works by movement of lithium ions between the cathode and anode. Such a mechanism should work forever, but storage and use at an elevated temperature has been observed to decrease some battery performance over time.

Solution

Funded by an Innovate UK A4I grant, Echion collaborated with the National Physical Laboratory, using secondary-ion mass spectrometry (SIMS) to characterise the surface composition of lithium-ion battery electrodes; and with ISIS using neutron diffraction at the Polaris instrument, to study the bulk atomic structure by investigating crystallographic changes taking place within the electrode. Pre-prepared cells aged at different temperatures were examined and analysis was then conducted to understand ageing mechanisms by comparing the electrodes before and after cycling.

Benefits

Neutron diffraction indicated negligible change in the bulk structure of the electrodes, which proves that the crystal structure itself remained stable. SIMS indicated elemental differences

in the surface composition, indicating that cycle life issues are more related to overall cell design and surface effects, rather than the bulk of the mixed niobium oxide electrode. This research allows Echion to focus their research into solving these issues, and will accelerate the adoption and commercialisation of Echion's next-generation ultra high-power, fast-charging cell material systems. Longer life cycles will be a key benefit to industrial users from manufacturers of buses, trains and ferries to mining and farming, implementing environmental and public health improvements in reducing harmful gases and particulate matter, in line with the UK government's Net Zero goals.

“Our work with ISIS Neutron and Moun Source has been an important part of the development of our niobium-based anode material, XNO®. The facilities and expertise available have given us insights and information that we wouldn't have been able to access by other means”

Dr. Fiona Coomer - R&D Programme Manager,
Echion Technologies



Why use neutrons?



Study structure

Neutron wavelengths are comparable to the spacings of atoms and molecules.



Study dynamics

Neutron energies are comparable to the time scales of molecular diffusion, vibrations and rotations.



Study magnetism

The neutron's magnetic moment can be used to study the microscopic magnetic properties of materials.



Penetration power

Neutrons can penetrate deep into matter (including many different metals) enabling the study of large samples – even within complex sample environments.



Non-destructive

As a non-destructive, non-invasive probe, neutrons are suitable for the characterisation of delicate and precious samples.



Versatile sample environments

Sophisticated sample environments enable measurements under operating conditions – including extreme temperatures and pressures.



Sensitivity to light elements

The neutron scattering power of nuclei varies in a random manner such that lighter atoms (e.g. H, Li) can be studied in the presence of heavier ones.



Isotopic contrast

Neutrons are sensitive to different isotopes of the same element, so isotopic substitution (e.g. H/D) can be used to highlight specific structural features.



Complementarity

Neutron scattering is highly complementary to other techniques, such as X-ray scattering, electron microscopy, magnetic resonance and computational methods.

How to work with ISIS

ISIS offers industrial users access to advanced analytical techniques and expert scientific and technical support for materials characterisation. Access options include proprietary use, academic partnerships, grant funded access, and the Industrial Collaborative Research and Development (ICRD) program.

For more information, email ISISindustry@stfc.ac.uk to discuss the most suitable method to solve your challenge.

