The Chemistry (and some Physics) of ‘a Better Battery’

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Lithium-ion batteries have become ubiquitous in laptops, cell phones, and electric vehicles. As this industry rapidly grows, so too does the demand for new battery designs that improve factors such as cost, safety, and lifetime. However, there is no such thing as ‘a better battery’, because as applications become more diverse, so too must battery designs. That is, a battery that is optimized for one application may be unsuited for any other. The result is that modern lithium-ion batteries have very complex and often very specialized cell chemistries and geometries.

This presentation will give an overview of how university research applying relatively basic organic chemistry, materials science, and analytical methods has been used to understand the underlying chemistry and physics of modern, industrially relevant lithium-ion batteries. It will be emphasized that the field benefits greatly from – and even requires – interdisciplinary collaboration, especially between theoretical/modelling activities and experimental researchers. Specific topics will include:

i) Electrolyte additives – compounds added to the electrolyte solution on the order of a few weight percent that can improve cell lifetime and safety by orders of magnitude. How do they work and how can we invent new ones?;

ii) Electrolyte salts and solvents – increased ion conductivity and decreased solvent viscosity are routes to increased power and energy density. How can we choose the right solvent mixture or invent a new salt?; and

iii) Positive Electrodes – the size and shape of electrode particles will determine their lifetime and directly affect the power capability of a cell. To determine the ideal morphology, we combine solid-state NMR spectroscopy, newly developed *operando* optical microscopy, and a finite-element method (FEM) model.

Biogram:

David Hall is an Associate Professor in Battery Technology at the University of Stavanger (UiS) in Norway. His research focuses on fundamentals and applications of interfacial electrochemistry for sustainable energy storage. His scientific interests are especially related to improving understanding of physico-chemical processes at electrode-electrolyte interfaces. Before joining UiS in 2023, he was a Research Associate in Prof. Clare Grey’s group in the Department of Chemistry of the University of Cambridge and a Project Lead for the Faraday Institution Degradation Project, a UK-wide research consortium studying lithium-ion battery lifetime. He was also a By-Fellow and a Director of Studies in Natural Sciences at Hughes Hall, one of the constituent colleges of the University of Cambridge.

Hall first studied chemistry and materials science at Western University in London, Canada. He then researched nickel-based catalyst materials for sustainable hydrogen production at the National Research Council of Canada and the University of Ottawa, supervised by Prof. Barry MacDougall and Dr. Christina Bock. He received a Postdoctoral Fellowship at Dalhousie University in Halifax, Canada, where he researched characterization methods, electrolyte additives, electrolytes for fast charging, and additive synthesis for lithium-ion batteries in Prof. Jeff Dahn’s research group. He has also worked in industry at the Nuclear Waste Management Organization in Toronto as a Corrosion Scientist and Project Manager of academic, government, and industrial research projects.