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Advanced multi-scale and multi-modal 3D imaging and modelling of porous anode microarchitecture and shape changes in rechargeable zinc-based batteries

The increasing need of reliable and sustainable energy supply, storage and portability, combined with global industrial competition, imposes a stringent schedule for battery research and development. Among the different technologies available nowadays, rechargeable zinc-based batteries are promising candidates owing to their comparatively high specific energy, abundant and distributed raw-material resources, moderate cost, environmental friendless and safety. The successful applications of rechargeable Zn batteries are still hindered by various technical pitfalls, a crucial one being their limited cycle life due to uncontrolled morphological changes of the anode upon applying discharge/charge cycles. The textural and geometrical properties of the pore network, including pore size distribution, shape, connectivity and tortuosity, as well as the anode shape changes brought about by cycling, play a crucial role in ionic transport in batteries and electrolyte flow in particulate-anodes, controlling their final electrochemical properties. These properties depend on the anode microstructure, electrolyte composition, use of chemical additives and are a function of the power applied to the battery, representing significant challenges for battery characterization and energy storage applications. An accurate estimation of the percolating networks of ionic conductors and fluid transport properties in the porous electrode material is essential to decipher the battery performance in terms of capacity loss when cycling and can be derived through the integration of optimized anode manufacturing processes, electrochemical characterization and morpho-textural analyses of the battery components and assembled cells. The recent advances in X-ray and neutron 3D imaging techniques, in static and dynamic conditions, through a multi-scale approach coupled with computational modelling simulating the cycling behaviour of batteries, can offer a deeper understanding of how the pore network properties influence fluid transport and their impact on the battery operation.
In this talk the result of investigation of Zn-based batteries cycling for traditional and innovative electrolyte chemistries and electrode configurations, at current densities and depths of discharge of practical interest, will be presented.

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