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SPEAKER SERIES

PRESENTS

Concentration polarization and dendrite initiation in alkali metal batteries

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Room: Zoom
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LECTURE ABSTRACT

Next-generation high-energy batteries require rechargeable metal anodes, but hazardous dendrites tend to form during recharging, causing short-circuit risk and capacity loss, even with hard and stiff ceramic electrolytes, by mechanisms that still remain elusive. In this seminar, we will demonstrate a rigorous analysis of the lithium dendrite formation in liquid electrolytes, through the intimate combination of operando experiments and novel transport models. Our results demonstrated the necessity to differentiate Li whiskers from Li dendrites, induced from different physical processes. Resolving the interfacial instability and metal whiskers led to an ideally smooth, non-porous, ingot-type Na metal plating, which enabled the anode-free Na metal full cells with a record-high retention rate of 99.93% per cycle at 3C charge and discharge. Chronopotentiometry tests of this ideal metal electrode revealed an inverse correlation between the penetration overpotential and the pore size of the separator, which can be captured by a new model we named as the Young-Laplace overpotential. Novel electrochemical tests of garnet-type cubic Li7-xLa3Zr2-xTaxO12 ceramic electrolytes confirmed a similar polarization and dendrite initiation mechanism through grain boundaries. Our theoretical and experimental discoveries suggest that the success of alkali metal batteries relies on the rational control of both the interfacial kinetics and the bulk ion transport.

SPEAKER BIOSKETCH

Dr. Bai obtained his Bachelor's degree in Automotive Engineering and PhD degree in Mechanical Engineering from Tsinghua University in Beijing, China, in 2007 and 2012, respectively. He completed his postdoctoral training in the Department of Chemical Engineering at MIT, prior to joining Washington University in St. Louis as a tenure-track Assistant Professor in the Department of Energy, Environmental and Chemical Engineering in 2017. His research group is specialized in combining mesoscale operando experiments with physics-based mathematical models to achieve precision understanding and rational engineering of battery electrodes. Dr. Bai has published in scientific journals including Science, Energy & Environmental Science, Joule, Advanced Energy Materials, Nature Communications, Nano Letters, etc. His won the Oronzio and Niccolò De Nora Foundation Young Author Prize from the International Society of Electrochemistry (ISE) in 2014, and the Prize for Electrochemical Materials Science from ISE in 2018. He received the NSF Career Award in 2021.

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