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ABSTRACT:

The Soret and Seebeck Effects and Dendrite Growth in Metal-Anode Batteries

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There is widespread interest in metallic lithium battery anodes due to their low electrochemical potential and high theoretical energy capacity. However, lithium metal anodes are susceptible to the growth of dendrites, which reduce cell lifetime and are a significant safety risk. Intentionally applied external thermal gradients are a proposed strategy to mitigate dendrite growth on lithium–metal anodes, potentially improving battery safety and lifetime [1,2]. Small temperature differences across the electrodes produce large thermal gradients across the cell due to the thinness of the separator. These large gradients can lead to thermodiffusion in the electrolyte. We include the ionic Soret and Seebeck effects in sharp interface and phase field models of interfacial evolution to study how thermodiffusion affects dendrite growth [3]. We demonstrate that thermal gradients can suppress dendrite growth and that they can also significantly delay dendrite growth. We identify a critical thermal gradient, beyond which dendrites are fully suppressed. These predictions qualitatively agree with the experimental literature and explain why dendrite suppression by thermal gradients is sensitive to the applied current density. Growth can also be accelerated unintentionally by the thermal gradient, which provides crucial insight for the design of electrolytes, cell geometries, and thermal management systems.

[1] R. Carter and C.T. Love, *ACS Appl. Mater. Interfaces* 2018, 10, 26328–26334.

[2] R. Carter, T.A. Kingston, R.W. Atkinson, M. Parmananda, M. Dubarry, C. Fear, P.P. Mukherjee, C.T. Love, *Cell Rep. Phys. Sci.* 2021, 2, 100351.

[3] A.F. Chadwick, J. Zhang, M.W. Swift, D.L. Chopp, M.D. Johannes and P.W. Voorhees, 2025. *ACS Energy Letters*, 10(12), pp.6281-6287.