David T. Boyle

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Academic Background

Stanford University 2017 - Present

- Ph.D. Candidate in Chemistry
  Advisor – Prof. Yi Cui
  Physical Electrochemical Approaches to Understand how the Electrolyte Impacts Kinetic Processes within Lithium Batteries

James Madison University 2013 - 2017

- Bachelor of Science in Chemistry – ACS Certified Materials Chemistry, *Magna Cum Laude*
  - Minor in Materials Science

  Advisor – Prof. Ashleigh E. Baber
  Honors Thesis—Elucidation of Active Sites for the Reaction of Ethanol on TiO_2/Au(111)

Awards/Research Funding

NSF – GRFP Fellow 2018-2023
National Science Foundation – Graduate Research Fellowship

ACS Award in Physical Chemistry 2017
James Madison University Department of Chemistry and Biochemistry

Degesch America Award 2017
James Madison University Department of Chemistry and Biochemistry

Polocsay Award in Undergraduate Research 2016
James Madison University Department of Chemistry and Biochemistry

C-CLEAR Research Experience for Undergraduates (REU) 2016
Colorado State University Department of Chemistry

Research Experience for Undergraduates (REU) Scholarship 2015
James Madison University College of Math and Science

Second Century Scholarship for Science, Technology, Engineering, and Mathematics (STEM) 2013-2017
James Madison University

Publications

18. Kim, S. K.; Kong, X.; Vilá, R. A.; Huang, W.; Chen, Y.; **Boyle, D. T.**; Yu, Z.; Wang, H.; Bao, Z.; Qin, J.; Cui, Y Potentiometric Measurement to Probe Solvation Energy and Its Correlation to Lithium Battery Cyclability *J. Am. Chem. Soc.* **2021**, *Articles ASAP.*
    DOI: 10.1021/jacs.1c03868

17. Chen, H.; Yang, Y.; **Boyle, D. T.**; Jeong, Y. K.; Xu, R.; Vasconcelos, L. S.; Huang, Z.; Wang, H.; Wang, H.; Huang, W.; Li, H.; Wang, J.; Gu, H.; Matsumoto, R.; Motohashi, K.; Nakayama, Y.; Zhao, K.; Cui Y. Free-standing ultrathin lithium metal–graphene oxide host foils with controllable thickness for lithium batteries *Nature Energy* **2021**, *In Press.*

DOI: 10.1038/s41560-021-00833-6

16. **Boyle, D. T.***; Huang, W.*; Wang, H.; Li, Y.; Chen, H.; Yu, Z.; Zhang, W.; Bao, Z.; Cui, Y. Corrosion of lithium metal anodes during calendar ageing and its microscopic origins *Nature Energy* **2021**, *6*, 487-484.
DOI: 10.1038/s41560-021-00787-9

15. Wang, H.; Zhu, Y.; Kim, S. K.; Pei, A.; Li, Y.; **Boyle, D. T.**; Wang, H.; Zhang, Z.; Ye, Y.; Huang, W.; Liu, Y.; Xu, J.; Li, J.; Liu, F.; Cui, Y Underpotential lithium plating on graphite anodes caused by temperature heterogeneity *PNAS* **2020**, *117*, 29453-29461.
DOI: 10.1073/pnas.2009221117

14. Xu, J.; Xiao, X.; Zhang, Z.; Wu, Y.; **Boyle, D. T.**; Lee, H. K.; Huang, W.; Li, Y.; Wang, H.; Li, J.; Zhu, Y.; Chen, D.; Mitch, W.; Cui, Y. Designing a Nanoscale Three-phase Electrochemical Pathway to Promote Pt-catalyzed Formaldehyde Oxidation *Nano Lett.* **2020**, *20*, 8719-8724.
DOI: 10.1021/acs.nanolett.0c03560

13. Oyakhire, S. T.; Huang, W.; Wang, H.; **Boyle, D. T.**; Schneider, J. R.; Paula, C.; Wu, Y.; Cui, Y.; Bent, S. F. Revealing and Elucidating ALD-Derived Control of Lithium Plating Microstructure *Adv. Energy Mat.* **2020**, *10*, 2002736.
DOI: 10.1002/aenm.202002736

12. Ye, Y.; Chou, L. Y.; Liu, Y.; Wang, H.; Lee, H. K.; Huang, W.; Wan, J.; Liu, K.; Zhou, G.; Yang, Y.; Yang, A.; Xiao, X.; Gao, X.; **Boyle, D. T.**; Chen, H.; Zhang, W.; Kim, S. K.; Cui, Y. Ultralight and fire-extinguishing current collectors for high-energy and high-safety lithium-ion batteries *Nature Energy* **2020**, *5*, 786-793.
DOI: 10.1038/s41560-020-00702-8

11. Chen, H.; Zhou, G.; **Boyle, D. T.**; Wan, J.; Wang, H.; Lin, D.; Mackanic, D.; Zhang, Z.; Kim, S. K.; Lee, H. R.; Wang, H.; Huang, W.; Ye, Y.; Cui, Y. Electrode design with integration of high tortuosity and sulfur-philicity for high-performance lithium-sulfur battery *Matter* **2020**, *2*, 1602-1605.
DOI: 10.1016/j.matt.2020.04.011

10. Huang, W.; Wang, H.; **Boyle, D. T.**; Li, Y.; Cui, Y. Resolving nanoscopic and mesoscopic heterogeneity of fluorinated species in battery solid-electrolyte interphases by cryogenic electron microscopy *ACS Energy Lett.* **2020**, *5*, 1128-1135.
DOI: 10.1021/acsenergylett.0c00194

9. **Boyle, D. T.**; Kong, X.; Pei, A.; Rudnicki, P. E.; Shi, F.; Huang, W.; Bao, Z.; Qin, J.; Cui, Y. Transient Voltammetry Reveals the Electron Transfer Kinetics of Lithium Metal Anodes. *ACS Energy Lett.* **2020**, *5*, 701-709.
DOI: 10.1021/acsenergylett.0c00031

8. Huang, W.; Wang, J.; Braun, M. R.; Zhang, Z.; Li, Y.; **Boyle, D. T.**; McIntyre, P. C.; Cui, Y. Dynamic Structure and Chemistry of the Silicon Solid-Electrolyte Interphase Visualized by Cryogenic Electron Microscopy. *Matter* **2019**, *1*, 1232-1245.
DOI: 10.1016/j.matt.2019.09.020

7. Huang, W.*; Attia, P. M.*; Wang, H.; Renfrew, S. E.; Jin, N.; Das, S.; Zhang, Z.; **Boyle, D. T.**; Li, Y.; Bazant, M. Z.; McCloskey, B. D.; Cheuh, W. C.; Cui, Y. Evolution of the Solid−Electrolyte Interphase on Carbonaceous Anodes Visualized by Atomic-Resolution Cryogenic Electron Microscopy. *Nano Lett.* **2019**, *19*, 5140-5148.

DOI: 10.1021/acs.nanolett.9b01515

6. Chen, H.; Pei, A.; Lin, D.; Xie, J.; Yang, A.; Xu, J.; Lin, K.; Wang, J.; Wang; H.; Shi, F.; **Boyle, D. T.**; Cui, Y. Uniform High Ionic Conducting Lithium Sulfide Protection Layer for Stable Lithium Metal Anode. *Adv. Energy Mat.* **2019,** *9*, 1900858. DOI: 10.1002/aenm.201900858
5. Huang, W.*; **Boyle, D. T.***; Li, Y.; Li, Y.; Pei, A.; Chen, H.; Cui, Y. Nanostructural and Electrochemical Evolution of the Solid-electrolyte Interphase on CuO Nanowires Revealed by Cryogenic Electron Microscopy and Impedance Spectroscopy. *ACS Nano* **2019**, *13* (1), 737-744. DOI: 10.1021/acsnano.8b08012
4. Deponte, M. C.; Wilke, J. A.; **Boyle, D. T.**; Gillum, M. Z; Schlosser, D. A.; Lam, V. H.; Kaleem, H.; Maxwell, E. M.; Baber, A. E. Low–Temperature Exchange of Hydrogen and Deuterium between Molecular Ethanol and Water on Au(111). *Surface Science* **2018**, *680*, 1-5. DOI: 10.1016/j.susc.2018.10.001
3. Li, Y.*; Huang, W.*; Li, Y.*; Pei, A.; **Boyle, D. T.**; Cui, Y. Correlating Structure and Function of Battery Interphases at Atomic Resolution with Cryoelectron Microscopy. *Joule* **2018**, *2* (10), 2167-2177. DOI: 10.1016/j.joule.2018.08.004
2. Shi, F.; Pei, A.; **Boyle, D. T.**; Xie, J.; Yu, X.; Zhang, X.; Cui, Y. Lithium Metal Stripping Beneath the Solid Electrolyte Interphase. *Proc. Nat. Acad. Sci.* **2018**, *115* (34), 8529-8534. DOI: 10.1073/pnas.1806878115
1. **Boyle, D. T.;** Wilke, J. A.; Palomino, R. M.; Lam, V. H.; Schlosser, D. A.; Andahazy, W. J.; Stopak, C. Z.; Stacchiola D. J., Rodriguez, D. J.; Baber, A. E. Elucidation of Active Sites for the Reaction of Ethanol on TiO_2/Au(111). *J. Phys. Chem. C* **2017**, *121* (14), 7794-7802. DOI: 10.1021/acs.jpcc.6b11764

*Co-first authors

Research Experience

Stanford University – Advisor: Prof. Yi Cui 2017- Present Stanford, CA

Physical Electrochemistry of Lithium Metal Anodes

- Initiated a new program within the research group focusing on understanding how electrolyte chemistries influence lithium metal anodes
- Showed that the electron-transfer kinetics of lithium metal anodes are consistent with the framework of Marcus Theory using transient voltammetry with ultramicroelectrodes
- Correlated the nanostructure of lithium battery interphases to macroscopic electrochemical impedance measurements during the formation of the interphase
- Studied the growth of passivation films on lithium metal anodes and its relation to electrolyte chemistry and battery lifetime
- Trained and mentored new Ph.D. and masters students of the lab

James Madison University – Advisor: Prof. Ashleigh Baber 2014-2017 Harrisonburg, VA

Adsorption and Chemistry of Ethanol on Au(111) and TiO_2/Au(111) Model Catalysts

- Constructed and maintained a thermal desorption ultrahigh vacuum chamber

- Used temperature programmed desorption (TPD) and surface characterization methods to understand the role of distinct surface sites on ethanol adsorption and chemistry on Au(111) & TiO_2/Au(111)
- Evaluated the role of surface preparation on the selectivity of ethanol reaction on TiO_2/Au(111)
- Designed experiments and established the research direction of the lab
- Trained and mentored new members of the lab

Colorado State University – Advisor: Prof. James Neilson 2016 Fort Collins, CO
Formation Pathways of Copper Oxides with Low-Temperature Metathesis
- Used air-free synthetic techniques and powder X-ray diffraction (PXRD) to investigate the solid-state formation pathway of copper oxides

Selected Presentations

6. **Boyle, D. T.**, Cui, Y. *Space Power Workshop | The Aerospace Corporation* "Corrosion of Lithium Metal Anodes and its Microscopic Origins", Los Angeles, CA (Virtual), April 22, **2021**; oral.
5. **Boyle, D. T.** *Battery Modeling Webinar Series* "Corrosion of Lithium Metal Anodes and its Microscopic Origins"; Carnegie Mellon University (Virtual), March 30, **2021**; oral. (Invited)
4. **Boyle, D. T.**, Wilke, J. A., Lam, V. H., Baber, A. E. *253rd ACS National Meeting,* "Elucidating distinct Au(111) and TiO_2/Au(111) surface sites for the selective oxidation of ethanol to acetaldehyde"; San Francisco, CA, April 2, **2017**; poster.
3. **Boyle, D. T.**, Wilke, J. A., Lam, V. H., Baber, A. E. *68th Southeast Regional Meeting of the American Chemical Society*, "Low temperature adsorption of ethanol on TiO_2/Au(111) inverse model catalysts"; Columbia, SC, October 25, **2016**; oral.
2. **Boyle, D. T.**, Martinolich, A. J., Neilson, J. R. *68th Southeast Regional Meeting of the American Chemical Society*, "Understanding the formation of copper (II) oxide through solid-state metathesis"; Columbia, SC, October 24, **2016**; poster.
1. **Boyle, D.T.**, Andahazy, W. J., Stopak, C. Z., Lam, V. H., Schlosser, D. A., Boeckmann, D., Baber, A. E. *251st ACS National Meeting*, "Adsorption and Reactivity of Ethanol on Au(111)-Based Inverse Model Catalysts"; San Diego, CA, March 14, **2016**; poster.

Teaching/Mentoring Experience

Stanford University Stanford, CA
Graduate Teaching Assistant 2017-2018
- CHEM 151: Inorganic Chemistry I
- CHEM 2&3: Organic Chemistry II & III
- CHEM 31X: Chemical Principles Accelerated

James Madison University Harrisonburg, VA
Teaching Assistant Spring 2016
- CHEM 270: Inorganic Chemistry I

Lab and Software Experience

Working experience with instrumentation:

- Thermal gravimetric analysis (TGA), infrared spectroscopy (FT-IR, ATR-IR), nuclear magnetic resonance spectroscopy (^{1}H, ^{13}C, ^{31}P NMR, ^{7}Li), photolithography, UV-Vis & fluorescence spectroscopy, gas chromatography (GC), mass spectrometry (GC-MS, TPD), and high-performance liquid chromatography (HPLC), atomic force microscopy (AFM), Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), linear scan voltammetry (LSV), chronoamperometry, Coulometry, battery cycling: Arbin,

Software experience:

- Fluent with Python Programming Language (SciPy, NumPy, Matplotlib) and MATLAB
- Fluent with SciFinder, Scopus, Mendeley, and RefWorks

Workshops:

- Extreme Crystals Weekend Workshop
    - University of Nevada Las Vegas High Pressure Science and Engineering Center (HiPSEC)