Sinclair R. Combs

(425) 890-2621 | sinclaircombs@mines.edu | Golden, CO, 80401 | Google Scholar | LinkedIn | 0000-0002-8982-0288

Summary Statement

I am a self-driven, dedicated, and curious individual working in solid-state materials chemistry research for next-generation battery applications. My educational background includes a B.S. in chemistry, having completed a research-based thesis in semiconducting polymer blends, and a B.A. in mathematics, with my thesis focused on differential equation derivations of quantum mechanical fundamentals. Currently, I am an applied chemistry Ph.D. candidate at Colorado School of Mines and work on a research project at the National Renewable Energy Laboratory. My research aims to design and characterize solid-state inorganic lithium-ion conductors, focusing on the crystallography of disordered materials and atomic-scale ion transport properties.

Core Qualifications

- Research experience in solid-state materials chemistry for next-generation lithium-ion battery applications
- Solid-state synthesis in air-free environments, including mechanochemical methods
- Crystallographic analysis, with a focus on highly-disordered and complex crystal systems (i.e., high defect concentration, planar disorder, etc.)
- X-ray diffraction and total scattering techniques for structural characterization
- Electrochemical measurement techniques, such as electrochemical impendence spectroscopy and chronopotentiometry
- Specialized structure modeling software development in the Python programming language; additional experience with TeX, Java, and C/C++
- Advanced mathematical experience with differential equations and group theory
- Extensive mentoring and cross-discipline collaborative experience

Education

Ph.D., Applied Chemistry, in progress — Expected 2026
Colorado School of Mines — Golden, CO
"Disordered materials design of metal halide ion conductors for all-solid-state battery applications"
(Advisor: Dr. Annalise E. Maughan)

Bachelor of Science, Chemistry — May 2021
Pacific Lutheran University — Tacoma, WA
Cum Laude, Departmental Honors
"Blending electronic & ionic conductive polymers for use in p-doped organic electrochemical transistors"
(Advisor: Dr. Dean Waldow)

Bachelor of Arts, Mathematics — May 2021
Pacific Lutheran University — Tacoma, WA
Cum Laude, Departmental Honors
"Derivations of the Schrödinger equation in multiple dimensions and coordinate systems"
(Advisor: Dr. Daniel J. Heath)

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Research Experience

Graduate Research Assistant Oct 2021 - Current
Maughan Lab, Department of Chemistry, Colorado School of Mines Golden, CO
National Renewable Energy Laboratory Golden, CO

- Solid-state materials design and synthesis of ternary metal halide lithium-ion conductors guided by first-principles predictive calculations
- Detailed structural analysis of highly-disordered crystal structures, including characterization of point defects and planar disorder
- X-ray total scattering techniques in polycrystalline materials (i.e., XRD, PDF)
- Software design (Python) for planar disorder modeling in non-layered crystal systems informed by diffraction measurements
- Ion transport property measurement and characterization using electrochemical techniques (i.e., impedence spectroscopy, potentiometery, galvanostatic cycling, etc.)

Undergraduate Research Assistant July 2020 - May 2021
Waldow Lab, Department of Chemistry, Pacific Lutheran University Tacoma, WA

- Blending electronically-conductive P3HT polymers and novel block co-polymer ion conductors for use as the active semiconductor layer in organic electrochemical transistors
- Design and synthesis of solid-state single-ion conducting block co-polymers for lithium-ion battery applications
- Collaboration with Dr. David Ginger research group at the University of Washington.

Advanced Organic Laboratory Jan 2020
Department of Chemistry, Pacific Lutheran University Tacoma, WA
Completion of two total organic synthesis project over a 4-week timeframe – polymerization, Grignard reagent synthesis for carbon-carbon bond formation

Organic Special Projects Laboratory Feb 2019 - May 2019
Department of Chemistry, Pacific Lutheran University Tacoma, WA
Development of professional-level organic synthesis and methodology development of pre-cursor organics for solid-state polymerization.

Advanced Experimental Experience

HFIR HB-2A Neutron Powder Diffractometer January 2024
High Flux Isotope Reactor, Oak Ridge National Laboratory
Utilizing high-resolution neutron powder diffraction to probe structural and dynamical changes of the lithium sublattice as a function of aliovalent substitution fraction in metal halide materials (*Proposal Title: Evolution of the Li sublattice upon substitution in* Li_3MCl_6)

APS Beamline 11-ID-B Dec 2022
Advanced Photon Source, Argonne National Laboratory
Performing *operando* total scattering measurements on substituted metal halides to understand

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how local structure of the bulk solid electrolyte dynamically evolves during electrochemical cycling (*Proposal Title: Operando XPDF: Cycling-induced local structure rearrangement of bulk substituted metal halide solid electrolytes*)

APS Beamline 11-BM-B July 2022; April 2023
Advanced Photon Source, Argonne National Laboratory
Utilizing high-resolution X-ray powder diffraction to reveal detailed disordered structures as a function of amount of chemical substitution into parent A_3MX_6 solid electrolyte materials
(*Proposal Title: Aliovalent Substitution of Ternary Metal Halide (A_3MX_6) Materials*)

Teaching Experience

Mines Chemistry Python Workshop August 2024
Department of Chemistry, Colorado School of Mines Golden, CO
Created materials for and taught introductory Python skills to other chemistry graduate students.

Live Help Tutor July 2022 - September 2023
Paper Education America Inc. Remote
Subjects: Physical Sciences and Math

Chemistry Lab Teaching Assistant Aug 2021 - May 2022
Department of Chemistry, Colorado School of Mines Golden, CO
Courses: Principles of Chemistry I and II (CHGN 121 and 122)

Private Tutor Dec 2020 - July 2021
A Little Creative LLC.; Self-Employment Tacoma, WA
Subjects: Physical Sciences and Math

Math Coursework Grader Sep 2020 - May 2021
Department of Mathematics, Pacific Lutheran University Tacoma, WA
Courses: Introduction to Proofs (MATH 317)

Chemistry Lab Teaching Assistant Sep 2018 - May 2021
Department of Chemistry, Pacific Lutheran University Tacoma, WA
Courses: Chemistry of Life (CHEM 105), General Chemistry I (CHEM 115), Organic Chemistry I (CHEM 331), Organic Special Projects Laboratory (CHEM 336), and Physical Chemistry I – Thermodynamics (CHEM 341)

Other Work Experience

Library Circulation Desk Assistant Sep 2018 - May 2021
Mortvedt Library, Pacific Lutheran University Tacoma, WA

Aide & Assistant Teacher for Summer Camps Jun 2018 - Aug 2018
Youth & Family Programs, Pacific Science Center Seattle, WA

Volunteer Experience

Colorado Reptile Human Society (CORHS)
Shelter Volunteer

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Bright MINDS (Multisensory Intensive Dyslexia Support) Program
Middle School Dyslexia Outreach Panel Volunteer

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Publications & Presentations

Combs, S.R.; Maughan, A.E. "PyFaults: A Python Tool for Stacking Fault Screening" *J. Appl. Cryst. In Review.*

Berquist, Z.; **Combs, S.R.**; Maughan, A.E.; Teeter, G. "Virtual electrode XPS experiments on $Li_{3-x}Sc_{1-x}Zr_xCl_6$ ($x \approx 0.3$): Oxygen-mediated interface passivation on metallic lithium anodes" *ACS Appl. Mater. Interfaces. In Review.*

Combs, S.R.; Maughan, A.E. "Stacking Faults Modify Lithium-ion Migration Pathways in $Li_{3-x}Sc_{1-x}Zr_xCl_6$ Solid-State Metal Halides" *In Preparation.*

Kothakonda, M.; **Combs, S.R.**; Maughan, A.E.; Gorai, P. "Predictions and Insights into Aliovalent Doping of Solid Electrolytes Li_3MCl_6 (M = Sc, Y)" *In Preparation.*

Combs, S.R.; Todd, P.K.; Gorai, P.; Maughan, A.E. "Editors' Choice—Review—Designing Defects and Diffusion through Substitutions in Metal Halide Solid Electrolytes" *J. Electrochem. Soc.*, **2022**, *169*, 040551. [doi]

Combs, S.R.; Maughan, A.E. "Influence of stacking disorder on ion conduction mechanisms in ternary metal halide solid-state electroytes", **ACS Fall 2024 Conference** (2024).

Combs, S.R.; Maughan, A.E. "Doubling Defect Dimensionality: Modeling Stacking Faults in Metal Halide Li-Ion Conductors", **ID4 All-Hands Meeting, Harvard University** (2024).

Combs, S.R.; Maughan, A.E. "Doubling Defect Dimensionality: Modeling 2-D Stacking Disorder in Metal Halide Ion Conductors", **ACS Rocky Mountain Regional Meeting** (2023).

Combs, S.R.; Maughan, A.E. "Expanding Defect Dimensionality: Modeling Stacking Faults in Metal Halide Li-ion Conductors", **Colorado Center for Advanced Ceramics Conference** (2023).

Combs, S.R.; Gorai, P.; Maughan, A.E. "Disordered Materials Design of Metal Halide Solid Electrolytes for Fast Ion Conduction in All-Solid-State Batteries", **Mines Graduate Research & Discovery Symposium** (2023) and **ADSE Young Researcher Conference** (2023).

Combs, S.R.; Gorai, P.; Maughan, A.E. "Disordered Materials Design of Metal Halide Solid Electrolytes for Fast Ion Conduction", **Rocky Mountain Solid State Chemistry Workshop** (2023).

Combs, S.R.; Gorai, P.; Maughan, A.E. "Defect Studies in Halide Solid Electrolytes for High-Voltage Battery Applications", **C3E Women in Clean Energy Symposium** (2022).

Combs, S.R.; Gorai, P.; Maughan, A.E. "Defect Studies in Solid Halide Electrolyte Materials for High-Voltage Battery Applications", **Mines Graduate Research & Discovery Symposium** (2022).

Combs, S.R.; Waldow, D.A. "Blending electronic and ionic conductive polymers for use in p-doped organic electrochemical transistors", **ACS Conference for Undergraduate Research**

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(2021) and **Murdock College Science Research Conference** (2021).

Fellowships, Honors & Awards

Outstanding Young Woman College Student In STEM Award Nominee March 2024
9th Annual Colorado Women's Day, IX Power Foundation

Best-Judged Talk Awardee August 2023
Colorado Center for Advanced Ceramics Conference, Colorado School of Mines

2nd Place Poster in Environment & Energy Research April 2023
Graduate Research & Discovery Symposium, Colorado School of Mines

Poster Presentation Awardee Jan 2023
Rocky Mountain Solid State Chemistry Workshop; University of Colorado, Boulder

NSF Institute for Data Driven Dynamical Design (ID4) Fellowship April 2022
Colorado School of Mines

2nd Place Poster in Environment & Energy Research April 2022
Graduate Research & Discovery Symposium, Colorado School of Mines

ACS Outstanding Organic Chemistry Senior May 2021
Department of Chemistry, Pacific Lutheran University

Dean's List Spring 2018, Fall 2019, Spring 2020
Pacific Lutheran University

Languages

English
Native Speaker

Norwegian
Limited Working Proficiency