

RACHEL N. GAINES, PH.D.

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SUMMARY

Chemical engineer with 6+ years of research experience in electrocatalytic reaction engineering & 11 years leading teams of 5-30 individuals in academic, government, and private sectors

Core expertise:

- Reaction engineering and process development for electrochemical sensing and upgrading of complex mixtures, including radioisotope production media, crude glycerol, flue gas, hydrocarbons, and PFAS
- Flow reactors (microfluidic, MEA, RFB) & batch reactors in acidic, alkaline, and neutral conditions
- High-throughput Design of Experiments (DoE), e.g., response surface methodology, mixture designs
- 12 publications (6 first-author, 2 corresponding-author) & 14 presentations (6 invited)
- Primary author of 3 successful funding proposals to internal & external agencies

EDUCATION

Ph.D., University of Illinois Urbana-Champaign

August 2025

Department of Chemical and Biomolecular Engineering

Advisor: Paul J.A. Kenis | Lab manager (2022 – 2025)

Thesis: Flow Electrooxidation of Glycerol for Industrial-Scale Applications

B.S., Appalachian State University

August 2019

Department of Geological and Environmental Sciences, *summa cum laude*

Minors: Biology; Sport Science & Coaching

RESEARCH EXPERIENCE

Postdoctoral Researcher, Isotope Applications Research Group, ORNL

August 2025 – present

Project scopes: (1) *Electrochemically sense oxidation states of complex isotopic mixtures to reduce process cost and improve waste management;* (2) *Electrocatalytically degrade complex organic waste from radioisotope production in acidic MEA reactors, increasing production space and reducing process hazards.*

- Designed and executed new project developing electrochemical sensing techniques for complex mixtures in radioisotope production processes, including scoping and formal hazard analyses
- Applied statistical Design of Experiments (DoE) to evaluate electrocatalytic degradation of complex production waste in acidic PEM membrane electrode assembly (MEA) electrolyzers
- Developed production-critical remote monitoring capabilities by writing a customizable Python program through SCPI and VISA for electrochemical data acquisition and pump operation, increasing data precision from 0.4 to 60 points per minute while saving \$20k+ in instrument costs
- Recruited by program manager to bridge gaps between data science, manufacturing teams, and experimental R&D; first electrochemical engineering specialist in a group of >20

Graduate Research Fellow & Laboratory Manager, Kenis Group, UIUC

August 2020 – July 2025

Project scope: *Electrocatalytically upgrade complex waste from biodiesel production, including pairing with CO₂ reduction and water reduction, using alkaline microfluidic flow reactors & MEAs.*

- Started new research thrust on alkaline flow electrolysis in microfluidic flow reactors for electrooxidative complex waste valorization, resulting in 7 successful projects, >\$500k in follow-on funding, and scale-up interest from 2 multinational corporations

[continued on pg. 2]

- Assessed precious- and non-precious metal catalysts (Au, Pt, Ni) for use in oxidative waste glycerol valorization / water reduction in 2 manuscripts, correlating process-scale behavior and related mechanistic underpinnings to waste impurities
- Investigated flow battery electrolytes (V3/4+,5/6+; TEMPO0/+/-OH) in a multi-institution team for spatiotemporal decoupling of electrocatalytic reactions
- Coupled electrolysis of multiple impure waste streams (dilute CO2 electroreduction / waste glycerol electrooxidation) in an MEA reactor with capture and purification units, demonstrating first stable integrated system for decentralized waste carbon capture and co-conversion
- Used SEM, EDX, and other materials characterization techniques to assess degradation of carbon-fiber substrates under oxidative accelerated stress testing conditions
- Established first HPLC system in the group, including system acquisition, maintenance, and MATLAB analysis development, improving data reproducibility and analytical efficiency
- Used high-throughput DOE to reduce reaction optimization time from 1.5 months to <1 week
- Authored >20 standard operating procedures and training manuals while onboarding ~20 new group members over 4 years

Universities Research Association Research Fellow, Sandia National Labs **May – August 2024**

Project scope: Assess short-chain (recalcitrant) PFAS degradation using bulk electrolysis systems and high-throughput statistical Design of Experiments (DoE) approaches.

- Secured 100% project funding for an original research proposal (<10% of proposals funded), leveraging differentiated technical capabilities at Sandia
- Recruited by two staff scientists to contribute to two different summer projects
- Designed and built reactor setup using existing supplies, resulting in \$0 materials spend
- Used high-throughput DoE experimentation to optimize reaction process in <3 weeks

Graduate Researcher, NEXUS Project, Appalachian State **May – December 2019**

Project scope: Evaluate and reduce impact of waste from a pilot-scale anaerobic digestion system.

- Secured 100% funding for a 1-year internal grant proposal on cold-climate anaerobic digestion
- Recruited by department head & represented department to Board of Trustees
- Evaluated waste composition of a pilot anaerobic digestion plant using drying and pyrolysis
- Quantified methane production from a proposed pilot-scale digester facility and made recommendations for methane sequestration using available substrates, eliminating 1.8 tons of waste emissions per year

PROFESSIONAL EXPERIENCE

Commercialization Analyst, Office of Technology Management, UIUC **May – October 2023**

- Evaluated invention disclosures, market potential, and IP strategy for emerging technologies

Research Analyst, Million Patients Cured **May – August 2020**

- First non-founding employee
- Conducted data analysis and market research to support early-stage product development

Academic Success Coach (Athletic Educational Mentor), Appalachian State **January – May 2020**

- Provided academic mentoring and performance support for at-risk student-athletes

PUBLICATIONS

12 total publications: 6 first-author & 2 corresponding-author

*: equal contributions | ^: corresponding

Peer-Reviewed

1. Sibal, A.P.; **Gaines, R.N.**; Friel, B.E.; Kenis, P.J.A.; Stillwell, A.S. Turning waste into value: Technoeconomic analysis and life cycle assessment of biodiesel-derived crude glycerol electrooxidation. *Environmental Science & Technology*, 2026. DOI: 10.1021/acs.est.5c16857
2. Zhao, Y.; **Gaines, R.N.**; Rojas, J.; Romo, A.I.B.; Kenis, P.J.A.; Rodriguez-Lopez, J. Valorization of glycerol through 2,2,6,6-tetramethyl-1-piperidine-N-oxyl (TEMPO)-catalyzed electrochemical oxidation with high C3 product selectivity: Impact of stirred bulk versus flow electrolysis. *ChemElectroChem*, 2025. DOI: 10.1002/celc.202500337
3. **Gaines, R.N.**; Sibal, A.P.; Bradley, A.M.; Griebler, J.J.; Shah, V.M.; Friel, B.E.; Rogers, S.A.; Stillwell, A.S.; Kenis, P.J.A. Electrolysis for valorization of industrially-sourced crude glycerol. *ACS Sustainable Chemistry & Engineering*, 2025. DOI: 10.1021/acssuschemeng.5c03028
4. Harris, L.C.; **Gaines, R.N.**; Hua, Q.; Lindsay, G.S.; Griebler, J.J.; Kenis, P.J.A.; Gewirth, A.A. Effect of glycerol concentration on rate and product speciation for Ni and Au-based catalysts. *Physical Chemistry Chemical Physics*, 2025. DOI: 10.1039/D4CP04013A
5. **Gaines, R.N.**[^]; LaFond, J.A.; Krawchuck, J.A.; Bays, N.R.; Kruse, S.M.; Kruichak, J.N. Statistical design of experiments enables rapid exploration of perfluorobutane sulfonate degradation. *ECS Advances*, 2025. DOI: 10.1149/2754-2734/ad865
6. **Gaines, R.N.**[^] Flow electrolyzers for reaction scaling. *Nature Reviews Clean Technology*, 2025. DOI: 10.1038/s44359-024-00003-3
7. **Gaines, R.N.**; Kleimenhagen, B.A.; Griebler, J.J.; Harris, L.C.; Gewirth, A.A.; Rogers, S.A.; Kenis, P.J.A. Optimization of the glycerol electrooxidation reaction using statistical design of experiments. *Journal of the Electrochemical Society*, 2024. DOI: 10.1149/1945-7111/ad537c

In Revision/Review

8. Brögsen, L.*; **Gaines, R.N.**^{*^} Engineering principles for scaling flow electrolysis. In revision, *Nature Reviews Clean Technology*.
9. Kim, J.; Yen, P.Y.; Bradley, A.M.; **Gaines, R.N.**; Kenis, P.J.A.; Zavala, V. Harnessing flexibility from inflexible systems: A case study in electrolysis. In revision, *Industrial & Engineering Chemistry Research*. Preprint: 10.26434/chemrxiv.15001860/v1
10. Woo, H.K.; Lee, B.; **Gaines, R.N.**; Tang, S.; Kenis, P.J.A.; Cai, L. Unbiased tandem system for simultaneous methane and glycerol upgrading to formic acid under ambient conditions. In revision, *Advanced Science*.
11. **Gaines, R.N.**^{*}; Sit, C.Y.*; Shah, V.M.*; Moy, K.K.*; Kenis, P.J.A. Electrocatalytic Valorization of Complex Waste Streams in an Integrated Capture, Scrubbing, and Conversion System. In review, *Energy & Environmental Science*.

In Preparation/Submitted

12. Bradley, A.M.; **Gaines, R.N.**; Elayan, H.; Lu, B.; Rios, Y.; Chavez, O.; Kenis, P.J.A. Process-informed assessment of crude glycerol electrooxidation. In preparation.

PROPOSALS & FUNDING

Funded/Awarded

Sandia National Laboratories URA fellowship proposal (award rate ~10%)	2024
TechnipFMC fellowship proposal (one to two awardees at the university per year)	2023
Appalachian State internal research grant	2019

Submitted & Competitive

Postdoctoral research proposal, Los Alamos National Laboratory	2025
• Awarded; not funded due to sponsor constraints	
Pauling Fellowship proposal, Pacific Northwest National Laboratory	2025
• Advanced to second round (~10% of proposals)	
• Independently authored before receiving staff scientist support	

SELECTED PRESENTATIONS

1. **Gaines, R.N.** Let's talk trash: Electrochemistry turns waste into products. Finalist, *Your Science in a Nutshell* competition, Oak Ridge National Laboratory, July 2026.
2. **[Invited]** Trash CAN do that: Electrocatalytic reaction engineering for upgrading of complex industrial wastes. *Distinguished Young Scholars Seminar series, Department of Chemical and Biomolecular Engineering, University of Washington*, July 2026.
3. **[Invited]** Optimizing the flow electrooxidation of industrial waste glycerol. *Photovoltaics and Materials Technology Organization, Sandia National Laboratories*, July 2025.
4. **[Invited]** Reaction engineering for waste-to-value electroconversions. *Faraday Technology*, May 2025.
5. **[Invited]** Reaction engineering for waste-to-value electroconversions. *Materials Synthesis and Integrated Devices Group, Los Alamos National Laboratory*, January 2025.
6. **[Invited]** Engineering waste glycerol electrooxidation. *Radioisotope Science and Technology Division, Oak Ridge National Laboratory*, December 2024.
7. **Gaines, R.N.**; Sibal, A.P.; Friel, B.E.; Shah, V.M.; Stillwell, A.S.; Kenis, P.J.A. Investigating crude glycerol electrooxidation. *ECS Fall 2024*, Honolulu, HI, October 2024.
8. **Gaines, R.N.** Enhancing short-chain PFAS degradation. *Universities Research Association Lightning Talks, Sandia National Laboratories*, virtual, July 2024.
9. **[Invited]** What do I do with a degree in environmental science? *Geological and Environmental Sciences, Appalachian State University*, virtual, April 2024.
10. **Gaines, R.N.**, Kleimenhagen, B.A., Griebler, J.J., Kenis, P.J.A. Glycerol electrooxidation in flow electrolyzers. 2nd place poster, *Chemical & Biomolecular Engineering Research Symposium, University of Illinois Urbana-Champaign*, October 2023.
11. **Gaines, R.N.**; Sibal, A.P.; Griebler, J.J.; Gaddam, R.; Harris, L.C.; Kleimenhagen, B.A.; Keshireddy, A.; Gewirth, A.A.; Rodriguez-Lopez, J.; Rogers, S.A.; Stillwell, A.S.; Kenis, P.J.A. Glycerol electrooxidation in flow electrolyzers. *ECS Fall 2023, Gothenburg, Sweden*, October 2023.
12. **Gaines, R.N.**; Zhao, Y.; Kleimenhagen, B.A.; Keshireddy, A.; Gaddam, R.; Sibal, A.P.; Gewirth, A.A.; Stillwell, A.S.; Rodriguez-Lopez, J.; Kenis, P.J.A. Electrochemical valorization of glycerol in flow electrolyzers. Poster, *ACS Spring 2023, Indianapolis, IN*, March 2023.

SELECTED HONORS & AWARDS

Distinguished Young Scholars Seminar, <i>University of Washington</i>	2026
WiscProf Future Faculty Program, <i>University of Wisconsin – Madison</i>	2026
Your Science in a Nutshell competition finalist, <i>Oak Ridge National Laboratory</i>	2026
URA Research Fellow, <i>Sandia National Laboratories</i>	2024
Best Practice in Communication, <i>Society of Women Engineers</i>	2023
TechnipFMC Research Fellow, <i>University of Illinois Urbana-Champaign</i>	2023
NCAA Woman of the Year nominee, <i>Appalachian State University</i>	2020
Provost's Fellow, <i>Appalachian State University</i>	2019
Hirschvogel Foundation Fellow, <i>Appalachian State University</i>	2019
Outstanding Leadership in Environmental Science, <i>Appalachian State University</i>	2019
USA Field Hockey national team member	2017 – 2021

SERVICE

Peer Reviewer	2025 – present
• ACS Sustainable Chemistry & Engineering • Advanced Science (Wiley)	
Session Chair & Competition Judge , ORPA Conference & WDTS Program, ORNL	2026
• ORPA: Chaired & served as a competition judge for sessions in chemistry & chemical ecology Moderated small-group networking sessions on leadership and academic career paths • WDTS: Competition reviewer for abstracts submitted by junior scientists and visiting teachers	
Deputy Director & Publicity Coordinator , weSTEM Conference, UIUC	2023 – 2025
• Coordinated programming, logistics, and outreach for a conference serving ~150 attendees	
Social Media Coordinator , Graduate Society of Women Engineers, UIUC	2022 – 2023
• Managed digital communications and engagement strategy for a 200-member organization	
Communications Chair , ChBE Graduate Student Advisory Committee, UIUC	2021 – 2022
• Facilitated departmental communication efforts and served as a student-faculty-staff liaison	

TEACHING & MENTORING

Graduate Students – 2 total

- Students advanced through program milestones while earning a DFI fellowship and an NSF-GRFP Honorable Mention

Undergraduate & Post-Baccalaureate Students – 6 total

- 3 students matriculated into PhD programs, including an awarded NSF-GRFP
- 3 students entered industry roles

Teaching Assistant – 4 semesters

- Cross-Curricular Design, Thermodynamics & Chemical Reaction Engineering (spring & fall 2022)
- Introduction to Environmental Science (summer 2019)
- Introduction to Hydrology (spring 2019)