

## Andrew Z. Haddad, Ph.D. Inorganic Electrochemistry

### Lawrence Berkeley National Laboratory | Energy and Technology Area

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### Education

**2012-2017**     **Ph.D. University of Louisville, Louisville, KY, USA**

Conn Center for Renewable Energy, Department of Chemistry, College of Science

**Dissertation:** *“Homogeneous and Heterogeneous Ligand-Centered Electro-Catalytic H<sub>2</sub> Evolution and Oxidation by exploiting redox non-innocence”*

Supervisors: Prof. Craig A Grapperhaus and Prof. Robert M. Buchanan

**Awards:** (1) John Richard Binford Memorial Award (Best Dissertation Award in entire university) (2) Robert Pack Memorial Award (Best dissertation in department of Chemistry) (3) Magna Cum Laude

**2008-2012**     **B.S. Chemistry University of Louisville, Louisville, KY, USA**

**Thesis:** Sulfur Alkylation and De-alkylation of a Di-molybdenum SO Bridge

**Advisor:** Prof. Mark E. Noble

**Awards:** Magna Cum Laude

### Work Experience

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**June 2017— Present:**     **ITRI-Rosenfeld Postdoctoral Fellow, Lawrence Berkeley National Laboratory, Berkeley, CA, USA**

**Energy Storage and Distributed Resources Division, Energy and Technologies Area**  
**Supervisors: Dr. Robert KostECKI and Prof. Ashok J. Gadgil**

**Role separated into the following main tasks, i) project management of direct solar-thermal forward osmosis desalination of produced waters using solar responsive ionic liquids ii) conducting fundamental research for synthesis and development of ionic liquids for use as draw solutes and their implementation in FO treatment of produced water. iii) Development and synthesis of transition metal based intercalation materials for ion harvesting from sea and produced waters. iv) Fabrication and testing of carbon based ion exchange resin materials for desalination of brackish water. v) project management of fluoride removal technology licensed for use in India vi) conducting fundamental research for development and synthesis of new 2D-materials based on natural ores for fluoride removal**

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**Current Projects**     *Project Title: Direct Solar-Thermal Forward Osmosis Desalination of Produced Waters using solar responsive Ionic Liquids*

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	<p><i>Budget:</i> 880K over 2 years, Funding agency: Department of Energy</p> <p><i>Description:</i> Academic—Industry collaboration with the California Resource Corporation</p> <p><i>Role:</i> Management as well as lab work: Currently manage 2 Ph.D. students and 3 undergraduates, 1 additional post-doc. Lab-work includes development of FO setup integrated with a custom built solar heater, synthesis of ionic liquids, characterization (FTIR, UV-Vis, <sup>1</sup>H NMR, TD-NMR, 2D-NMR, DLS, SEM, viscosity, osmolality, DFT, MD) of ILs, selective absorber –emitter design and fabrication using sputtering techniques</p> <p><u><i>Project Title:</i> Electrochemically regenerated Ion exchange Resins and Novel Intercalation Materials for Desalination and Valuable Ion Mining from Sea and Brackish Water</u></p> <p><i>Budget:</i> 600K over two years, Funding agency: Lawrence Berkeley National Lab’s LDRD initiative</p> <p><i>Description:</i> Academic—Industry collaboration with Bosch GmbH</p> <p><i>Role:</i> Roles were separated into two tasks. <i>i) Development and synthesis</i> new intercalation materials based on transition metals that can be used for intercalation of sodium lithium and magnesium ions concurrently. Controlled release through electrochemical potential application in proper redox window. <i>ii) Fabrication and performance testing</i> of new carbon based electrodes doped with commercial ion exchange resins for desalination of brackish water.</p> <p><u><i>Project Title:</i> Scalable and Affordable Fluoride Removal (SAFR)</u></p> <p><i>Budget:</i> 300K over 2 years, Funding Agency: Industrial Technology Research Institute of Taiwan</p> <p><i>Description:</i> Academic-Industry collaboration with SATTVA India</p> <p><i>Role:</i> Project management of 2 two undergraduates as well as an international team of collaborators from SATTVA agency and ITT-Mumbai, as well as conducting fundamental research to develop newer and cheaper materials for fluoride removal. Material characterization (MAS-NMR, SEM, synthesis, cradle-to-grave life-cycle assessment, kinetic studies and mechanism interpretation)</p>
<b>Teaching</b>	<p><u>Guest Lecturer</u>, University of California Berkeley, The Water Planet: Department of Earth and Planetary Sciences, Summer 2018, 6 class sessions</p> <p><u>Guest Lecturer/Team Leader</u>, University of California Berkeley, Dev-Eng 201, Haas Business School, Fall 2018 (full semester)</p>
<b>Mentoring</b>	2 PhD students, 1 masters student, 6 undergraduate students, providing support with lab work, scientific writing, and good scientific practices.
<b>Outreach</b>	<p>Designed programs at LBNL for running hand on lab demonstrations for local Oakland and Berkeley middle and high schoolers.</p> <p>Participated in bring your child to work day with demonstrations for children.</p> <p>Editor for Water and Energy Nexus Special Issue, “<i>Roles of Energy and Food Elements in Water Security and Sustainability</i>”.</p> <p>Reviewer for environmental chemistry, inorganic chemistry, Advanced Sustainable Systems, and JACS</p>
<b>Aug 2012— May 2017</b>	<p><b>PhD student</b>, University of Louisville, Department of Chemistry, Louisville, KY, USA</p> <p>Supervisors: Prof. Craig A. Grapperhaus and Prof. Robert M. Buchanan</p> <p><i>Dissertation:</i> “<i>Homogeneous and Heterogeneous Ligand-Centered Electro-Catalytic H<sub>2</sub> Evolution and Oxidation by exploiting redox non-innocence</i>”</p> <p><i>Description:</i> Experimental and computational inorganic electrochemistry PhD requiring</p>

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multidisciplinary approach. Developed skills in inorganic and organic synthesis, electrochemical characterization, electrode fabrication, reaction mechanism interpretation, computational analysis, and fuel cell reactor design, and development of polymers.

*Key Techniques:* schlenk line synthesis, glove box work, potentiostat use, NMR, UV-Vis, FTIR, EPR, MATLAB, spin-coating, carbon paste electrode design, SEM, XRD, Gaussian and GAMES.

*Key Achievements:* First ever reported 2 examples of ligand centered reaction mechanism for hydrogen evolution and hydrogen oxidation. First ever reported 2 examples of reversible hydrogen evolution and hydrogen oxidation using same catalyst. First ever reported example of transition metal free hydrogen evolution and hydrogen oxidation. 3 NSF grants, 4 publications (all first author), 3 patents.

*Awards:* (1) John Richard Binford Memorial Award (Best Dissertation Award in entire university) (2) Robert Pack Memorial Award (Best dissertation in department of Chemistry) (3) Magna Cum Laude

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**Teaching** General and Organic Chemistry Lectures and Labs for UofL (1<sup>st</sup> and 2<sup>nd</sup> year undergraduates), 4 yrs  
Chemistry/Biology Teacher, St. James Academy High School, Louisville, KY, 2yrs

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**Mentoring** 1 PhD Student, providing support with lab work, scientific writing, and good scientific practices.

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**Aug 2010—** **R&D Intern**, Brown Forman Corporation, Louisville, KY, USA

**Aug 2012** Research and Development and food sciences division

*Supervisor:* Sherry Klaus

*Role:* Performed GC-MS and LCMS of aged distillate, as well as aided in formulation development of new flavorings for liquors. Gained extensive experience in fragrance and flavor development

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**Publications, Patents, total citations =100;h-index=4 (current as of 04/01/19)**

- 1. Solar Umbrella for regeneration of Thermo-responsive Ionic Liquids in Forward Osmosis**  
Andrew Z. Haddad, Akanksha Menon, Ravi Prasher, Jeffery Urban, Robert Kostecki  
*Energy and Environmental Science, 2019, in preparation*
- 2. Direct Solar-Thermal Desalination of Produced Waters**  
Robert Kostecki, Jeffery Urban, Ravi Prasher, Andrew Z Haddad, Akanksha Menon  
U.S. Provisional Patent Application, **2019**
- 3. Materials, Compounds, Their Preparation, Related Compositions, Catalysts, Electrochemical Cells, Fuel Cells, and Uses Thereof**  
Andrew Z. Haddad, Robert M. Buchanan, Craig A. Grapperhaus  
U.S. Provisional Patent Application No. 62/348,490. Issued: June 6, **2019**  
<https://patents.google.com/patent/US20190106385A1/en>
- 4. Advances in Brackish Water Desalination using Reverse Osmosis, and Capacitive Deionization: A Critical Review**  
Andrew Z. Haddad, Shu-Yuan Pan, Ashok J. Gadgil  
*Critical Reviews in Environmental Science and Technology, 2019,*  
*In preperation*
- 5. Towards Greener More Sustainable Manufactures of Bauxite-Derived Adsorbents for Water Defluoridation**

- Shu-Yuan Pan, Andrew Z. Haddad, J. Nathan Hohman, Ashok J. Gadgil  
*Environmental Science and Technology*, **2019**, *In preparation*
6. **Acid-Treated Thermally Activated Bauxite For Fluoride Removal From Water**  
Andrew Z. Haddad, Ashok J. Gadgil, Chinmayee Subban  
U.S. Provisional Patent Application serial no. 62/714,236. Filed August 3, **2018**
  7. **On the Conversion of Abundant Aluminum Ores to Highly-Activated Alumina for Water Remediation**  
Andrew Z. Haddad, J. Nathan Hohman, Corey Pilgrim, April M. Sawvel, Ashok J. Gadgil.  
*Advanced Sustainable Systems*, **2019**, DOI:  
<https://doi.org/10.1002/adsu.201900005>
  8. **Metal-Assisted Ligand-Centered Electrocatalytic Hydrogen Evolution upon Reduction of a Bis(thiosemicarbazone)Cu(II) Complex**  
Andrew Z. Haddad, Steve P. Cronin, Robert M. Buchanan, Craig A. Grapperhaus  
*Inorganic Chemistry* **2017**, 56 (18), pp 11254–11265 DOI:  
<http://pubs.acs.org/doi/10.1021/acs.inorgchem.7b01608>
  9. **Translation of Ligand-Centered HER Activity and Mechanism of a Rhenium-Thiolate from Solution to Modified Electrodes: A Combined Experimental and DFT Study**  
Andrew Z. Haddad, Wuyu Zhang, Brady D. Garabato, Pawel M. Kozlowski, Robert M. Buchanan, Craig A. Grapperhaus  
*Inorganic Chemistry* **2017**, 56 (4), pp 2177–2187  
DOI: <http://dx.doi.org/10.1021/acs.inorgchem.6b02829>
  10. **Compounds, Their Preparation, Related Compositions, Catalysts, Electrochemical Cells, Fuel Cells, and Uses Thereof**  
Andrew Z. Haddad, Robert M. Buchanan, Craig A. Grapperhaus  
U.S. Provisional Patent Application No. 62/348,420. Filed: June 10, **2016**  
ULRF 16082-02, <http://www.flintbox.com/public/project/29807/>
  11. **Beyond Metal-Hydrides: Non-Transition Metal and Metal-Free Ligand-Centered Electrocatalytic Hydrogen Evolution and Hydrogen Oxidation**  
Andrew Z. Haddad, Brady D. Garabato, Pawel M. Kozlowski, Robert M. Buchanan, Craig A. Grapperhaus  
*Journal of the American Chemical Society* **2016**, 138, 7844  
DOI: [10.1021/jacs.6b04441](https://doi.org/10.1021/jacs.6b04441)
  12. **Proposed Ligand-Centered Electrocatalytic Hydrogen Evolution and Hydrogen Oxidation at a Noninnocent Mononuclear Metal–Thiolate**  
Andrew Z. Haddad, Davinder Kumar, Kagna Ouch Sampson, Anna M. Matzner, Mark S. Mashuta, and Craig A. Grapperhaus.  
*Journal of the American Chemical Society* **2015**, 137 (29), 9238-9241.  
DOI: [10.1021/jacs.5b05561](https://doi.org/10.1021/jacs.5b05561)

## Presentations

1. **American Chemical Society International Conference**  
September **2013** Indianapolis, Indiana
  - **Presentation 1: Inorganic Chemistry: Homogeneous Ligand-Centered Proton Reduction** (Presenter)

- **Presentation 2: Invited Sci-Mixer:** *Homogeneous Ligand-Centered Proton Reduction* (Presenter)
- 2. **Gordon Research Conference: Inorganic Reaction Mechanisms**  
March 1-6, 2015 Galveston, Texas.
  - **Presentation:** *Homogeneous Ligand-Centered Hydrogen Evolution and Oxidation at a Mono-Nuclear Metal Thiolate.* (Presenter)
- 3. **Pacifi-Chem Research Conference**  
December 14-22, 2015 Honolulu Hawaii.
  - **Presentation 1:** *Redox Active Ligands: Ligand-Centered Electrocatalytic Proton Reduction and Hydrogen Oxidation* (Presenter; Winner Inorganic Division)
  - **Presentation 2:** *Synthesis, Characterization and Electrochemical Properties of New Tetra Coordinated Ni(ii) and Zn(ii) Complexes with New P<sub>2</sub>S<sub>2</sub> type Ligand Framework* (Co-Author)
  - **Symposium Talk:** *Redox-active metal-thiolates: Ligand-centered Electrocatalytic Proton Reduction/Hydrogen Oxidation* (Co-Author)
- 4. **Kentucky Academy of Sciences Annual Meeting**  
November 4-5, 2016 Louisville, KY (University of Louisville)
  - **Talk:** Homogeneous Ligand-Centered Electrocatalytic Hydrogen Evolution and Oxidation: *Exploiting Redox Non-Innocence to Drive Catalysis* (Presenter; 1<sup>st</sup> Place)
- 5. **Lawrence Berkeley National Laboratory: Energy and Technology Area Guest Lecturer**  
January 5, 2017 Berkeley, CA
  - Talk: Ligand-Centered Electrocatalytic Hydrogen Evolution and Oxidation: *Applying Water-Splitting for LBNL's Advanced CDI Technology* (Presenter)
- 6. **University of Louisville Graduate Research Conference: Three Minute Thesis Competition**  
March 24, 2017 Louisville, KY
  - Talk: Transition metal and Metal Free Hydrogen Production and Oxidation: A viable Path for the Future
- 7. **Lawrence Berkeley National Laboratory: Technology Pitch Competition**  
November 3, 2017 Berkeley, CA
  - Talk: Safe and Affordable Fluoride Removal (SAFR) Technology (winner)

8. **University of California Berkeley Guest Lecturer, The Water Planet:**  
Department of Earth and Planetary Sciences.  
Summer 2018, 4 class sessions
9. **University of California Berkeley Guest Lecturer/Team Leader, Dev-Eng 201**  
Haas Business School  
Fall 2018
10. **DOE Solar Energy Technologies Office Annual Conference**  
March 19-20, 2019 Oakland, CA
  - Poster Presentation: Direct Solar-Thermal Forward Osmosis Desalination of Produced Waters

### Laboratory Experience and Skills

- **Statistical Analysis:** Experience with R, SPSS, STATA, or other statistical languages
- **Electrochemistry**
  - Homo- and Heterogeneous catalysis, digital modeling of reaction mechanisms, kinetics, electrodeposition, electro-sensing, spectro-electrochemistry, electrochemical impedance spectroscopy (EIS), battery testing, electrode fabrication.
- **Inorganic and Organic Synthesis**
  - Extensive experience in air-free synthesis and Schleck-line technique, polymer synthesis, nanoparticle synthesis.
- **Fourier Transform Infrared Spectroscopy (FTIR and Near-IR)**
- **Thermogravimetric Analysis-Mass Spec (TGA-MS)**
- **Surface Electron Microscopy (SEM)**
- **Computational Chemistry/Analysis**
  - DFT, TD-DFT, Zero point energy, transition-states, intrinsic reaction coordinate calculations, Gaussian, Chemcraft, Qchem, expresso, cp2k, Mercury, Linux
- **X-Ray Photoelectron Spectroscopy (XPS)**
- **Powder X-ray Diffraction (XRD)**
- **Ultraviolet Spectroscopy (UV-VIS)**
- **NMR**
  - $^1\text{H}$ ,  $^{31}\text{P}$ ,  $^{13}\text{C}$ ,  $^{15}\text{N}$ , 2D
- **Electro-Paramagnetic Spectroscopy (EPR)**
- **Glove-Box Work**
- **Raman Spectroscopy**
- **Data Analysis**
- **Grant Writing**
- **Public Speaking**
- **Analytical Writing**
- **MATLab**
- **Teaching**
- **Project Design**
- **Project Management**
- **Grant Writing**
  - Three National Science Foundation (NSF) and one Kentucky Science and Engineering Research Fund (KSEF)

## Honors and Awards

- **2017:** Lawrence Berkeley National Lab Tech Pitch Competition- 1<sup>st</sup> place/People Choice
- **2017:** Awarded Robert Pack Memorial Award
- **2017:** Participation in NSF Innovation-Corp (I-CORP)
- **2017:** John Richard Binford Memorial Award (best PhD dissertation)
- **2017:** Graduate Deans Citation Award
- **2017:** Awarded ITRI-Rosenfeld Postdoctoral Fellowship at Lawrence Berkeley National Laboratory: research proposal on new technologies for desalination of brackish water using capacitive deionization.
- **2016:** Awarded first place in the graduate student oral presentation category at the Kentucky Academy of Sciences Annual Meeting
- **2016:** Awarded Council on Postsecondary Education Fellowship Award
- **2016:** School Of Interdisciplinary Studies Tuition Award
- **2015:** Winner of the Merck International Student Research Poster Presentation (Inorganic Division) Competition at the International Chemical Congress of Pacific Basin Societies (Pacifi-Chem) Conference. Honolulu, HI. December 2015
- **2014:** Kentucky Science & Engineering Research Grant #148-502-15-350; *Research (student) and Co-Author*
- **2013:** National Science Foundation Research Grant Funding Grant #1361728; *Research (student) and Co-Author*
- **2011:** Summer Research Opportunity Program (SROP), *Selected Applicant*, University of Louisville
- **2010:** Univ. of Louisville STEM-UTA-Program: Undergraduate Teaching Assistantship Appointment (*Instructed three classes per week or two labs per week each semester until graduation*)
- **2008:** University of Louisville Trustees Scholar
- **2007:** Kentucky Governor's Scholars Program, *participant and alum* – Major in International Relations; Minor in Integrated Mathematical Relationships

## List of Three References

1. A. Name: Craig A Grapperhaus; Phone: 502-852-5932  
B. Relationship: Thesis/Dissertation advisor  
C. Organizational Affiliation: Professor Chemistry University of Louisville  
D. Email: [craig.grapperhaus@louisville.edu](mailto:craig.grapperhaus@louisville.edu)
2. A. Name: Robert M. Buchanan; Phone: 502-852-6580  
B. Relationship: Co-Author/Collaborator  
C. Organizational Affiliation: Professor Chemistry University of Louisville  
D. Email: [bob.buchanan@louisville.edu](mailto:bob.buchanan@louisville.edu) / Robert.buchanan@louisville.edu
3. A. Name: Robert Kostecki; Phone: (510) 486-6002  
B. Relationship: Advisor  
C. Organizational Affiliation: Deputy Director of Energy and Technology Area, LBNL
4. D. Email: [R.Kostecki@lbl.gov](mailto:R.Kostecki@lbl.gov)
5. A. Name: Ashok J. Gadgil; Phone: 510-486-4651  
B. Relationship: Advisor

- C. Organizational Affiliation: Professor of Civil and Environmental Engineering at the University of California Berkeley and Senior Scientist at Lawrence Berkeley National Laboratory
- D. Email: [ajgadgil@lbl.gov](mailto:ajgadgil@lbl.gov)