McLain Evan Leonard Curriculum Vitae

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EDUCATION & CREDENTIALS

# Massachusetts Institute of Technology (MIT) (Dual Ph.D./M.S.CEP Program)

# Ph.D., Chemical Engineering

January 2021

• Thesis Title: Engineering Gas Diffusion Electrodes for Electrochemical Carbon Dioxide Upgrading

MIT

• Advisor: Professor Fikile R. Brushett

Current GPA: 4.6/5.0Minor: Electrochemistry

#### M.S.CEP, David H. Koch School of Chemical Engineering Practice

June 2017

Station 1: MedImmune Station 2: Woodside Energy

• Awarded Jefferson W. Tester Award

# Montana State University (MSU)

# B.S., Chemical Engineering

May 2015

GPA: 3.99/4.00 Minor: Economics

• Honors Baccalaureate with Distinction

• Magna Cum Laude

MSU Student Chapter President of The Electrochemical Society

# ENGINEERING EXPERIENCE

#### **Doctoral Candidate**

September 2015 to January 2021

Brushett Research Group, Massachusetts Institute of Technology

Engineering Gas Diffusion Electrodes for Electrochemical Carbon Dioxide Reduction Reactors

- Constructed a three-electrode gas-fed flowing liquid electrolyte reactor platform with Solidworksdesigned, CNC-machined components that can be used to evaluate the performance of gas diffusion electrodes functionalized with metal electrocatalysts
- Developed an experimental protocol to track porous electrode capacitance and product compositions with gas chromatography in long-duration electrolysis studies, which suggested that current-dependent electrode flooding is associated with diminished CO<sub>2</sub> reduction rates
- Designed and constructed a bubble-point pressure screening platform to evaluate liquid percolation thresholds & wettability of porous materials used as gas diffusion electrodes
- Investigated the intrinsic wettability of porous electrode material models with aqueous-organic liquid mixtures to motivate the modification of gas diffusion electrode microstructure and surface chemistry towards improving flooding management in gas-to-liquid CO<sub>2</sub> electrolyzers
- Evaluated two-phase fluid stability envelopes for representative gas diffusion electrode models as a function of the constituent porous layers microstructures and surface chemistries
- Constructed macro-homogeneous CO<sub>2</sub> electrolyzer transport models with two-phase flow (i.e., gas & liquid electrolyte) that are solved using commercial software packages (i.e., MATLAB & COMSOL)

Technoeconomic Analysis to Identify Market-viable Carbon Dioxide Reduction Products

- Used thermodynamics-based approach to determine minimum power inputs for carbon products
- Performed sensitivity analyses with commodity materials and electricity prices to determine break-even reactor voltage thresholds
- Identified carbon monoxide and formic acid as potentially market viable products

Laboratory Manual Editor

- Initiated and coordinated the 2020 revision of the Brushett Group Lab Manual
- Delegated revision responsibilities among group members
- Authored new standard operating procedures (SOPs) for the Energy Conversion Subgroup
- Typeset the Laboratory Manual with Adobe InDesign®

Laboratory Data Manager

- Organized and managed the group's data with a Dropbox file system
- Improved data collection from laboratory sensors with Python-based data recording routines

### **Graduate Consultant**

January 2017 to May 2017

Woodside Energy, Inc.

Pluto Feed Composition Modeling - Project Lead

- Developed a model to predict subsea natural gas well compositions for a network of offshore sites using onshore measurements from the Pluto LNG plant
- Validated operator heuristics composition lag times with model predictions for offshore-toonshore composition changes

Assessing Train Efficiency During Offshore Constrained Production at KGP

- Evaluated LNG train efficiencies at the Karratha Gas Plant (KGP) to inform future plant operation and turndown strategies in resource-constrained scenarios
- Recommended using individual compressor efficiencies as descriptors for overall train efficiency

#### MedImmune, LLC

Developing Automation to Enable a Self-Regulating Continuous Purification Process

- Developed an automated control system for continuous purification of biologic drug products using a simple, low-cost Arduino platform
- Enabled future functionality upgrades by a second group of MIT Graduate Consultants in 2018

Evaluating an in vitro Tool to Predict Bioavailability of Protein Therapeutics Upon Subcutaneous Injection

- Evaluated the feasibility of deploying a commercial in vitro screening platform for comparing the release rates of various subcutaneously-injected drug formulations
- Identified a low-cost, in-house alternative to the commercial solution

#### **Undergraduate Research Assistant**

January 2012 to May 2015

High-Temperature Materials Laboratory, Montana State University

Developing MAX-phase coatings for hot corrosion mitigation

- Advisor: Professor Roberta Amendola
- Fabricated thin-film MAX-phase coatings using magnetron sputtering physical vapor deposition
- Pursued Cr-Al-C thin-films for mitigating Type II hot corrosion in jet turbine combustion zones

High-temperature corrosion of electroless nickel-plated ferritic stainless steel for SOFC components

- Advisor: Professor Paul E. Gannon
- Investigated high-temperature corrosion of metallic interconnect components for solid oxide fuel cells (SOFC) under a dual hydrogen-oxygen environment in the absence of electrical current
- Concluded from SEM, EDS, and XRD of sample cross-sections that electroless nickel coatings did not protect the 441SS alloy from corrosion over 100 hour experiments at 800°C

# **Process Engineering Intern**

May 2014 to August 2014

IM Flash, LLC

- Implemented a process quality enhancement project in the Physical Vapor Deposition group
- Used Fab production data to improve the group's engineering processes
- Designed production defect reduction experiments to improve NAND wafer yield

#### **Intern Engineer**

The Boeing Company

- Worked with the Boeing Research & Technology 787 Wing & Propulsion Support group
- Optimized the application methods of critical aircraft sealants and surface finishes
- Designed protocols to evaluate methods by duration, feasibility, and material usage

TEACHING & MENTORING **EXPERIENCE** 

# Station Director - SGCE, Pasadena, TX, USA

Winter 2019

David H. Koch School of Chemical Engineering Practice

- Facilitated collaboration between the host company (SGCE) and MIT
- Advised and mentored MSCEP students during consulting projects
- Evaluated students' performances and assigned course grades

### Teaching Assistant - Analysis of Transport Phenomena (10.50)

Fall 2017

Massachusetts Institute of Technology Graduate Level Course

- Developed supplementary lectures and problems with solutions to enhance the course
- Held weekly 2-hour recitation section to expand beyond material covered during lecture
- Held weekly office hours to help students working through homework-specific problems
- Assisted with editing and grading of exams

### **Research Advisor and Mentor**

January 2017 to Present

Massachusetts Institute of Technology

•	Train and	supervise	undergraduate	students in	n laboratory	research activities

• Nicole Jacobsen (UROP), Anode electrocatalysis for $UO_2$ electrolyzers	winter 2020
• Nicholas Aiello (MITEI-UROP), Wettability of Gas Diffusion Electrodes	Summer 2019
• David Silverstein (UROP), MEAs for CO <sub>2</sub> electrolyzers	Fall 2018

• Geneva Casalegno (UROP), TEMPO-mediated alcohol oxidation

Spring 2018

#### LEADERSHIP

# Representative

2017 to 2020

Graduate Student Advisory Board, MIT Department of Chemical Engineering **President** 2014 to 2015

Electrochemical Society, Montana State University

2013 to 2014

**Treasurer** Electrochemical Society, Montana State University

Secretary

2012 to 2013

American Institute of Chemical Engineers, Montana State University

ChemE Car Competition Chair - Pacific Northwest Student Regional Conference

American Institute of Chemical Engineers, Montana State University

RESEARCH AWARDS

• Joseph W. Richards Summer Research Fellowship of The Electrochemical Society 2020

• IEEE Division Student Travel Award, 235th ECS Meeting, Dallas, TX, USA 2019 • National Science Foundation Graduate Research Fellowship - Finalist 2015

• Goldwater Scholarship

2014

2017

2013

ACADEMIC AWARDS

• Jefferson W. Tester Award, David H. Koch School of Engineering Practice

• ExxonMobil-MIT Energy Initiative Energy Fellowship 2015 • Most Outstanding Chemical Engineering Graduate, Montana State University 2015 • Balanced Leader Scholarship, Sigma Phi Epsilon, Montana State University 2012

LANGUAGES

**English** Spanish

Native Proficiency Limited Working Proficiency

SKILLS &

Computational

Courses MATLAB, COMSOL, Solidworks, Python, Git

#### Characterization

Gas chromatography (GC), High-pressure liquid chromatography (HPLC), SEM, EDS, UV/vis, XRD, XPS, Contact angle goniometry, Bubble point pressure measurement

#### Devices & Systems

Potentiostats, Three-electrode electrochemical cells, Flow cells, Electrolyzers, Mass flow controllers, Data acquisition (DAQ)

# Engineering & Economics

Kinetics, Thermodynamics, Transport Phenomena, Numerical Methods, Machine Learning, Systems Engineering, Electrochemistry, Electrical Engineering, Microeconomics, Macroeconomics, Development Economics, International Economics

# Machining & Fabrication

CNC mill machining, Laser cutting, Waterjet cutting, Catalyst spray-deposition, Membrane-electrode-assembly hot pressing decal transfer

# PROFESSIONAL MEMBERSHIPS

The Electrochemical Society

ACADEMIC MEMBERSHIPS

- Society of Energy Fellows
- Goldwater Scholars

#### **PUBLICATIONS**

- M. E. Leonard; M. J. Orella; N. Aiello; Y. Román-Leshkov; A. Forner-Cuenca; F. R. Brushett, "Editors' Choice—Flooded by Success: On the Role of Wettability in CO<sub>2</sub> Electrolyzers that Generate Liquid Products", *Journal of The Electrochemical Society*, 2020, 167(12), 124521.
- 2. M. J. Orella; M. E. Leonard; Y. Román-Leshkov; F. R. Brushett, "Automated Analysis of Contact Angle Goniometry Data Using DropPy", *Software X*, (In Review).
- 3. M. E. Leonard; L. E. Clarke; A. Forner-Cuenca; S. M. Brown; F. R. Brushett, "Investigating Electrode Flooding in a Flowing Electrolyte, Gas-Fed Carbon Dioxide Electrolyzer", *ChemSusChem*, 2020, 13(2), 400–411. Selected as a *Very Important Paper*
- 4. M. J. Orella; S. M. Brown; M. E. Leonard; Y. Román-Leshkov; F. R. Brushett, "A General Techno-Economic Model for Evaluating Emerging Electrolytic Processes", *Energy Technology*, 2019, 1–12.
- S. Sen; S. M. Brown; <u>M. Leonard</u>; F. R. Brushett, "Electroreduction of carbon dioxide to formate at high current densities using tin and tin oxide gas diffusion electrodes", *Journal of Applied Electrochemistry*, 2019, 49(9), 917-928.
- S. Sen; M. Leonard; R. Radhakrishnan; S. Snyder; B. Skinn; D. Wang; T. Hall; E. J. Taylor; F. R. Brushett, "Pulse Plating of Copper onto Gas Diffusion Layers for the Electroreduction of Carbon Dioxide", MRS Advances, 2018, 3(23), 1277–1284.
- S. Sen; B. Skinn; R. Radhakrishnan; <u>M. Leonard</u>; F. R. Brushett, "Investigation of Pulse-Reverse Electrodeposited Copper Electrocatalysts for Carbon Dioxide Reduction to Ethylene", *ECS Transactions*, 2017, 77(11), 933–946.
- 8. L. Aw; R. Amendola; P. E. Gannon; M. Leonard, "Type II Hot Corrosion Behaviors of Cr, Al, C Binary and Ternary Thin Film Coatings on Ni-201", *ECS Transactions*, 2015, 64(26), 149–159.
- 9. M. E. Leonard; R. Amendola; P. E. Gannon; W.-J. Shong; C.-K. Liu, "High-Temperature (800 °C) Dual Atmosphere Corrosion of Electroless Nickel-Plated Ferritic Stainless Steel", *International Journal of Hydrogen Energy*, 2014, 39(28), 15746–15753.

#### **PRESENTATIONS**

- M. E. Leonard; N. Aiello; L. E. Clarke; M. J. Orella; F. R. Brushett, "Wettability of Gas Diffusion Electrode Materials for CO<sub>2</sub> Reduction", *Oral Presentation*, 236th Meeting of the Electrochemical Society, Atlanta, GA, USA, 2019.
- M. E. Leonard; L. E. Clarke; A. Forner-Cuenca; S. M. Brown; F. R. Brushett, "Towards Understanding GDE Flooding in a Flowing Electrolyte CO<sub>2</sub> Reactor", *Oral Presentation*, 235th Meeting of the Electrochemical Society, Dallas, TX, USA, 2019.
- 3. <u>M. E. Leonard</u> "Engineering Porous Electrode for CO<sub>2</sub> Upgrading", *Oral Presentation*, Doctoral Student Seminar, MIT Department of Chemical Engineering, Cambridge, MA, USA, 2018.
- 4. B. Skinn; S. Sen; M. Leonard; R. Radhakrishnan; D. Wang; A. Forner-Cuenca; T. D. Hall; S. Snyder; F. R. Brushett; E. J. Taylor, "Pulsed Electrodeposition of Gas-Diffusion Electrocatalysts

- for  $CO_2$  Reduction", *Oral Presentation*, 234th Meeting of The Electrochemical Society, Cancun, Mexico, 2018.
- R. Radhakrishnan; B. Skinn; S. Sen; <u>M. Leonard</u>; T. D. Hall; S. Snyder; F. R. Brushett; E. J. Taylor, "Pulsed Electrodeposition of Gas Diffusion Electrocatalysts for CO<sub>2</sub> Reduction to Value-Added Products", *Oral Presentation*, 233rd Meeting of The Electrochemical Society, Seattle, WA, USA, 2018
- M. Leonard "Synthesis of Cr<sub>2</sub>AlC MAX-Phase Protective Coating on Ni-201 Substrate via Magnetron Sputtering", *Poster Presentation*, Montana Space Grant Consortium Research Symposium, Montana State University, Bozeman, MT, USA, 2014.
- M. Leonard "Performance of Electroless Nickel Plating on 441 Stainless Steel for SOFC Interconnect Applications", *Poster Presentation*, National Conference on Undergraduate Research, University of Wisconsin La Crosse, La Crosse, WI, USA 2013.