

YUANCHAO LI

CHEMICAL ENGINEER / ELECTROCHEMIST / FUEL CELL AND FLOW BATTERY EXPERT /

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EDUCATION

PhD, Chemical and Petroleum Engineering, University of Kansas, USA 2019
The Development of High Mass Specific Surface Area Rhodium Sulfide Catalysts for HOR/HER in H₂-Br₂ Fuel Cell
Committee: Dr. Trung Van Nguyen (chair), Dr. Xianglin Li, Dr. Juan J Bravo-Suárez, Dr. Kevin C. Leonard, Dr. Laurence R. Weatherley

MS, Applied Chemical Engineering, Tianjin University, CN 2014
Theoretical Exploration and Molecular Designing of Dye Sensitizer for Dye-sensitized Solar Cell
Advisor: Dr. Yaqing Feng

BEng, Chemical Engineering, Tianjin University, CN 2011

BS, Chemistry, Nankai University, CN 2011

HONORS & AWARDS

Chartered Chemist of Royal Society of Chemistry 2023

Outstanding Ph.D. Researcher Award Nomination 2019
(One candidate nominated per department)

Deutscher Akademischer Austauschdienst (DAAD) Fellowship 2013
(Stipend, travel, and insurance fellowship for research in Germany)

National Scholarship for Graduate Students of Chinese Ministry of Education 2012
(Top 1% Chinese graduate students)

RESEARCH EXPERIENCE

Los Alamos National Laboratory (LANL), Los Alamos, NM, USA 2023-present
Postdoctoral Research Associate, supervised by Dr. Jacob Spendelow

- Unitized regenerative fuel cell (URFC):
 - (1) Established baseline performance metrics for the URFC.
 - (2) Developed and implemented a standardized test protocol for URFC research.
 - (3) Engineering a durable and cost-effective titanium-less porous transport layer.

University of Kansas & Largo Clean Energy Inc., Lawrence, KS & Wilmington, MA 2022-2023

Postdoctoral Research Associate, supervised by Dr. Trung Van Nguyen (KU) and Mike Perry (LCE)

- Electrolyte Densification Process for Cost-Efficient Flow Battery Transport:

- (1) Innovated a method to transform low-concentration aqueous electrolytes into densified gel form without losing activity.
- (2) Reduced the transportation costs of flow battery electrolytes by 90%, translating to a 20% reduction in the overall capital cost of the flow battery system.
- (3) Discovered unique electrochemical properties in supersaturated electrolytes during this industry-focused research, paving the way for groundbreaking fundamental studies in a new domain of electrochemistry.

University of Kansas, Lawrence, KS, USA

2019-2023

Postdoctoral Researcher, supervised by Dr. Trung Van Nguyen

- Enhanced PEM Fuel Cell Efficiency through Hydrophobic Ionomer Surface Treatment:
 - (1) Engineered the ionomer surface of PEM fuel cells, achieving a significant 135% increase in peak power output.
 - (2) Collaborated with NIST scientists to analyze and determine the microscopic structures of the ionomer.
- Heterogeneous Ionomer Distribution Modeling in PEM Fuel Cells:
 - (1) Developed a comprehensive device model to mathematically represent PEM fuel cells with treated ionomer.
 - (2) Investigated the underlying mechanisms responsible for significant performance enhancements due to ionomer treatment.
 - (3) Proposed advanced material development strategies for further enhancement of PEM fuel cell performance.
- Hybrid Form High-Energy-Density Flow Battery for Grid-Scale Storage
 - (1) Co-invented, alongside my supervisor, a groundbreaking hybrid form (solid and liquid) flow battery, positioning myself as one of the two principal inventors in this pioneering study.
 - (2) Enhanced the storage energy density of the existing flow battery design 4-fold with minimal structural modifications.
 - (3) Mentored two undergrad students and one graduate student to conduct relevant research.

University of Kansas, Lawrence, KS, USA

2014-2019

Graduate Research Assistant, supervised by Dr. Trung Van Nguyen

- Advanced Rh_xS_y Synthesis for Enhanced HOR/HER Catalysis in H_2 - Br_2 Flow Battery:
 - (1) Achieved a doubling of the electrochemical surface area compared to the commercial BASF electrocatalyst through the synthesis of highly dispersed and active Rh_xS_y .
 - (2) Significantly enhanced the durability of HOR/HER catalysts, thereby rendering the H_2 - Br_2 flow battery more practical and reliable for use.

National Center of ChemE, Tianjin University, Tianjin, CN

2014-2019

Graduate Research Assistant, supervised by Dr. Yaqing Feng

- Exploring Structure-Activity Relationships in Dye-Sensitized Solar Cells

- (1) Created a comprehensive toolbox for analyzing the structure-activity relationship in dye-sensitized solar cells, encompassing aspects like charge transfer, optical transitions, and light-harvesting efficiency.
- (2) Designed and provided more efficient sensitizers to aid researchers in experimental work, enhancing the overall efficacy of dye-sensitized solar cells.

University of Saarland, Saarbrücken, Germany

Summer 2013

Visiting Researcher, supervised by Dr. Michael Springborg

- High-Throughput Porphyrin Screening for Dye-Sensitized Solar Cell Optimization: Devised a strategic framework for the efficient downselection of potential porphyrin-based sensitizer candidates for dye-sensitized solar cells (DSSC).

Shengli Chemical Co., LTD, Dongying, CN

Summer 2010

Research Assistant (Intern), supervised by Dr. Jiancheng Zhou

- Advancing High-Efficiency Demulsifiers for Heavy Oil Extraction: Assisted research staff with the development of high-efficiency demulsifiers for heavy oil.

RESEARCH INTERESTS

- | | |
|------------------------------------|-------------------------|
| • Material Science and Engineering | • Theoretical Chemistry |
| • PEM Fuel Cell | • Battery Modelling |
| • Flow Battery | |

TECHNICAL SKILLS

Synthesis & Characterization

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|-----------------------------|-----------------------------|
| • Electrocatalyst | • Electrode |
| • Electrolyte | • TEM, SEM, XRD, XPS, FT-IR |
| • Chemical Vapor Deposition | |

Device

- | | |
|-----------------|---------------------------------|
| • Fuel Cells | • United Regenerative Fuel Cell |
| • Electrolyzers | • Flow Batteries |

Computation

- Mathematical Modeling for Electrochemical Engineering
- DFT and MD Calculation
- Programming (Python and Matlab)

TEACHING & MENTORING

Teaching Assistantships

- “Momentum Transfer” (class #511, Chemical and Petroleum Engineering Department, KU)
- “Chemical Engineering Kinetics and Reactor Design” (class #522, Chemical and Petroleum Engineering Department, KU)

- “Design of Chemical Engineering” (class #613, Chemical and Petroleum Engineering Department, KU)

Undergraduate Research Supervisor

- Electrolyte Densification Process for Cost-Efficient Flow Battery Transport
- Hybrid Form High-Energy-Density Flow Battery for Grid-Scale Storage

Consultant for KU's Chem-E-Car Competition®

- Answered technical questions and provided suggestions to undergraduate competitors... (Chemical and Petroleum Engineering Department, KU)

PROFESSIONAL ACTIVITIES & AFFILIATIONS

Symposia Organized

- Session co-chair, “Large-Scale Energy Storage,” 239th Electrochemical Society meeting

Journals & Funding Reviewed

- | | |
|----------------------------------------------------|--------------------------------------|
| • <i>ACS Sustainable Chemistry and Engineering</i> | • <i>MITACS Foundation of Canada</i> |
| • <i>Journal of the Electrochemical Society</i> | • <i>Energies</i> |

Journal Edited

- Topic editor, *Catalysts*

PATENTS

1. Trung Van Nguyen and **Yuanchao Li**, “Flow battery Systems and Methods of Using the Same Cross-reference to Related Applications,” WO2021108244A1
2. Trung Van Nguyen and **Yuanchao Li**, “Osmosis Process Coupled with Production Operation for Vanadium Electrolyte Densification,” Patent under preparation by the University of Kansas

PUBLICATIONS (TOTAL PUBLICATIONS: 22; ORCID: 0000-0001-8728-1295)

Peer-Reviewed Journal Articles

1. **Yuanchao Li**, Joshua Abbey, and Trung Van Nguyen. “Electrochemical Properties and Performance of Supersaturated Vanadium (IV) and V (V) Electrolytes.” *Journal of The Electrochemical Society* 170.11 (2023): 110506.
2. **Yuanchao Li**, Natalie Linnell Schwab, Robert M. Briber, Joseph A. Dura, Trung Van Nguyen. “Modification of Nafion's Nanostructure for the Water Management of PEM Fuel Cells.” *Journal of Polymer Science* 61.8 (2023): 709-722.

3. **Yuanchao Li**, Spencer Thomas Mouron, Mike Perry, and Trung Van Nguyen*. "Vanadium Electrolyte Densification and Gel Formation Processes." *Industrial & Engineering Chemistry Research* 62.41 (2023): 16785-16793.
4. **Yuanchao Li**, and Trung Van Nguyen. "A One-Dimensional Model of a PEM Fuel Cell with the Cathode Catalyst Layer Hydrophobically Treated for Water Management." *Journal of The Electrochemical Society* 169, (2022): 114505
5. **Yuanchao Li**, and Trung Van Nguyen. "A Solid/Liquid High-Energy-Density Storage Concept for Redox Flow Batteries and Its Demonstration in an H₂-V System," *Journal of The Electrochemical Society* 169, (2022): 110509
6. Bahdad, Abdullah Omar O., **Yuanchao Li**, and Trung Van Nguyen. "Characterization of the Electrochemical Behavior of MnSO₄ with and without TiOSO₄ in H₂SO₄ Solution." *Journal of The Electrochemical Society* 168, no. 7 (2021): 070524.
7. Dowd, Regis P., **Yuanchao Li**, and Trung Van Nguyen. "Controlling the Ionic Polymer/Gas Interface Property of a PEM Fuel Cell Catalyst Layer During Membrane Electrode Assembly Fabrication." *Journal of Applied Electrochemistry* 50, no. 10 (2020): 993-1006.
8. **Yuanchao Li**, and Trung Van Nguyen. "High Hydrogen Evolution Reaction (HER) and Hydrogen Oxidation Reaction (HOR) Activity Rh_xS_y Catalyst Synthesized with Na₂S for Hydrogen-Bromine Fuel Cell." *Energies* 13, no. 15 (2020): 3971.
9. **Yuanchao Li**, and Trung Van Nguyen. "Synthesis and Evaluation of Rh_xS_y Catalyst with High Affinity for Nafion Ionomer for HOR/HER in a H₂-Br₂ Regenerative Fuel Cell." *Journal of The Electrochemical Society* 166, no. 10 (2019): F701.
10. **Yuanchao Li**, and Trung Van Nguyen. "Core-shell Rhodium Sulfide Catalyst for Hydrogen Evolution Reaction/Hydrogen Oxidation Reaction in Hydrogen-Bromine Reversible Fuel Cell." *Journal of Power Sources* 382 (2018): 152-159.
11. **Yuanchao Li**, and Trung Van Nguyen. "Synthesis and Evaluation of Rh_xS_y Catalyst with Functionalized Carbon for HOR/HER in H₂-Br₂ reversible Fuel Cell." *Journal of The Electrochemical Society* 165, no. 14 (2018): F1139.
12. Dowd Jr, Regis P., Ankit Verma, **Yuanchao Li**, Devon Powers, Ryszard Wycisk, Peter N. Pintauro, and Trung Van Nguyen. "A Hydrogen-Vanadium Reversible Fuel Cell Crossover Study." *Journal of The Electrochemical Society* 164, no. 14 (2017): F1608.
13. **Yuanchao Li**, and Trung Van Nguyen. "Core-shell Rhodium Sulfide Catalyst for HER/HOR in HBr Solution." *ECS Transactions* 72, no. 10 (2016): 19.
14. Zhang, Nuonuo, Bao Zhang, Lu Sun, **Yuanchao Li**, Yanbo Yang, Chencheng Fan, Xiaodong Xue, Jiaying Yan, Xianggao Li, and Yaqing Feng. "Influence of the Number of

Phenylethynyl Units Present in Porphyrin Sensitizer on Its Light Harvesting and Cell Performance.” *Research on Chemical Intermediates* 41, no. 11 (2015): 8713-8724.

15. Zhang, Nuonuo, Bao Zhang, Jiaying Yan, Xiaodong Xue, Xiao Peng, **Yuanchao Li**, Yanbo Yang, Chenggong Ju, Chencheng Fan, and Yaqing Feng. “Synthesis of π -A-Porphyrins and Their Photoelectric Performance for Dye-sensitized Solar Cells.” *Renewable Energy* 77 (2015): 579-585.
16. Liang, Yuxia, Xiaodong Xue, Weihong Zhang, Chencheng Fan, **Yuanchao Li**, Bao Zhang, and Yaqing Feng. “Novel D- π -A Structured Porphyrin Dyes Containing Various Diarylamino Moieties for Dye-sensitized Solar Cells.” *Dyes and Pigments* 115 (2015): 7-16.
17. Fan, Chencheng, Bao Zhang, **Yuanchao Li**, Yuxia Liang, Xiaodong Xue, and Yaqing Feng. “Application-Oriented Computational Studies on A Series Of D- π -A Structured Porphyrin Sensitizers with Different Electron-Donor Groups.” *Physical Chemistry Chemical Physics* 17, no. 45 (2015): 30624-30631.
18. **Yuanchao Li**, Yaqing Feng, Yating Wang, Chencheng Fan, Xiujun Liu, Xianggao Li, and Bao Zhang. “Design Of High-Performance Chlorine Type Dyes for Dye-Sensitized Solar Cells.” *International Journal of Quantum Chemistry* 114, no. 3 (2014): 222-232.
19. Yan, Jiaying, Yaqing Feng, Xiao Peng, **Yuanchao Li**, Nuonuo Zhang, Xianggao Li, and Bao Zhang. “Synthesis of β , β' -edge Fused, π -extended Porphyrins and Their Applications in the Dye-sensitized Solar Cells.” *Tetrahedron Letters* 54, no. 52 (2013): 7198-7201.
20. Liu, Xiujun, Chengjie Li, Xiao Peng, Yongzhu Zhou, Zhe Zeng, **Yuanchao Li**, Tianyi Zhang et al. “Performance of Four Artificial Chlorin-Type Sensitizers with Different Stereostructures in Dye-Sensitized Solar Cells.” *Dyes and Pigments* 98, no. 2 (2013): 181-189.
21. Jingjing Li, Kaiqi Fan, Libo Niu, **Yuanchao Li**, and Jian Song. “Effects Of Salt on The Gelation Mechanism Of a D-sorbitol-based Hydrogelator.” *The Journal of Physical Chemistry B* 117, no. 19 (2013): 5989-5995.
22. Zhang, Nuonuo, Yaqing Feng, **Yuanchao Li**, Xiao Peng, Chengzhi Gu, Xiaodong Xue, Jiaying Yan, Qinglong Chen, Xianggao Li, and Bao Zhang. “Synthesis And Characterization of Simple Trans-AB-Porphyrins for Dye-Sensitized Solar Cells.” *New Journal of Chemistry* 37, no. 4 (2013): 1134-1141.

Work-in Progress

Yuanchao Li, Tanvir Arman, Jacob Spendelow, “Comparative Analysis of Degradation Mechanisms in Low-Loading Pt Black Versus Pt/C in United Regenerative Fuel Cells (URFCs)”, in process.

Oral Presentations

1. “Molecular Structures and Electrochemical Activity of Oversaturated Electrolytes”, **Yuanchao Li**, Joshua Abbey, Nirala Singh and Trung Van Nguyen. Electrochemical Society annual meeting, Boston, MA, USA, May 2023. DOI: <https://doi.org/10.1149/MA2023-013731mtgabs>.
2. “Precipitation Mechanism of VOSO_4 in Oversaturated Electrolytes of the Solid-Liquid Storage Method in Vanadium Redox Flow Batteries”, **Yuanchao Li**, Joshua Abbey and Trung Van Nguyen. Electrochemical Society annual meeting, Boston, MA, USA, May 2023. DOI: <https://doi.org/10.1149/MA2023-013735mtgabs>.
3. “New Developments in the High-Energy-Density Solid-Liquid Storage Technology for Redox Flow Batteries”, **Yuanchao Li** and Trung Nguyen. Electrochemical Society annual meeting, Atlanta, GA, USA, Oct 2022. DOI: <https://doi.org/10.1149/MA2022-02143mtgabs>.
4. “Demonstration of the Hydrogen-Vanadium Flow Battery with a Novel High-Energy Storage”, **Yuanchao Li** and Trung Nguyen. Electrochemical Society annual meeting, Chicago, IL, USA. Jun 2021. DOI: <https://doi.org/10.1149/MA2021-013205mtgabs>.
5. “Highly Dispersed Rh_xS_y Catalyst on Carbon Support with High Nafion Affinity for HER/HOR in HBr Solution”, **Yuanchao Li** and Trung Van Nguyen. Electrochemical Society annual meeting, Seattle, WA, USA. May 2018. DOI: <https://doi.org/10.1149/MA2018-01/2/218>.
6. “New Process to Synthesize Rh_xS_y Catalyst by Na_2S and Pretreated Carbon for HER/HOR in HBr Solution”, **Yuanchao Li** and Trung Van Nguyen. 6th international forum of ACEEES, Tenerife, Spain. Dec 2017.
7. “New Process to Synthesize Rh_xS_y Catalyst by Na_2S and Pretreated Carbon for HER/HOR in HBr Solution”, **Yuanchao Li** and Trung Van Nguyen. Midwest meeting of ACS, Lawrence, USA. Dec 2017.
8. “New Process to Synthesize Rh_2S_3 Precursor for Rh_xS_y Catalyst for HER/HOR in HBr Solution by Na_2S and Pretreated Carbon”, **Yuanchao Li** and Trung Van Nguyen. Electrochemical Society annual meeting, New Orleans, MS, USA. Jun 2017. DOI: <https://doi.org/10.1149/MA2017-01/2/175>.
9. “Effect of Carbon Substrate Pretreatment on the ECSA and Activity of $\text{Rh}_x\text{S}_y/\text{C}$ Catalyst”, **Yuanchao Li** and Trung Van Nguyen. Electrochemical Society annual meeting, San Diego, CA, USA. Jun 2016. DOI: <https://doi.org/10.1149/MA2016-02/1/30>.
10. “A New Process to Synthesize the Rh_2S_3 Precursor for Rh_xS_y Catalyst for HER/HOR in HBr Solution”, **Yuanchao Li** and Trung Van Nguyen. Electrochemical Society annual meeting, Honolulu, HI. DOI: <https://doi.org/10.1149/MA2016-02/1/31>.
11. “Core-Shell Rhodium Sulfide as Catalyst for HER/HOR in HBr Solution”, **Yuanchao Li** and Trung Van Nguyen. Electrochemical Society annual meeting, San Diego, CA, USA. Jun 2016. DOI: <https://doi.org/10.1149/MA2016-01/3/391>.
12. “Improved $\text{Rh}_x\text{S}_y/\text{C}$ Catalyst Structure for Higher HOR/HER Activity”, **Yuanchao Li** and Trung Van Nguyen. Electrochemical Society annual meeting, Phoenix, AZ, USA. Oct 2015. DOI: <https://doi.org/10.1149/MA2015-02/1/30>.