

## Meiqi Yang (She/her/hers)

Department of Civil and Environmental Engineering, and the Andlinger Center for Energy and the Environment  
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### RESEARCH INTERESTS

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My research lies in designing advanced materials and separation techniques to improve the efficiency and reduce the cost for resource recovery from wastewater through data-driven modeling and advanced machine learning.

### EDUCATION

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**Princeton University** Princeton, NJ, USA  
**Ph.D.**, Environmental Engineering 2020 - 2025 (expected)  
**Ph.D. Thesis:** Enhancing Resource Recovery from Wastewater via Data-driven Material Engineering  
**Supervisor:** Dr. Zhiyong (Jason) Ren  
**Supervisory committee members:** Drs. Catherine A. Peters, Claire E White, Ryan S. Kingsbury, Liangbing Hu

**Yale University** New Haven, CT, USA  
**M.S.**, Environmental Engineering 2018 - 2019  
**Research Supervisor:** Drs. Menachem Elimelech and Shu Hu

**Shandong University** Shandong, China  
**B.S., (with honors)**, Environmental Science  
2014 - 2018

### EMPLOYMENT

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**Research Assistant, Energy Institute II, Yale University** New Haven, CT, USA  
**Projects:** Atomic Layer Deposition for Multifunctional Coatings and Ion Selective Membranes 2019 - 2020  
**Supervisor:** Drs. Menachem Elimelech and Shu Hu

### AWARDS & HONORS

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2024 Graduate Conferences Fellowship, Andlinger Center for Energy and the Environment  
2023 Graduate Conferences Fellowship, Andlinger Center for Energy and the Environment  
2020 - 2021 The Thomas J. Nelson \*68 and Mary Baker Nelson SEAS Fellowship  
May 2017 National Innovation and Entrepreneurship Training Program, Ministry of Education of the People's Republic of China. (Group Leader)  
2015 - 2016 Shandong University Scholarship and Merits Student, Shandong University

### RESEARCH EXPERIENCE & PROJECTS

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#### Evaporation and Crystallization for Resource Recovery

April. 2022 - Present Evaporative Crystallizer for Selective Mineral Extraction

- Design an efficient and self-concentrating crystallization method for the selective extraction of lithium from both brines and seawater;
- Synthesize novel 3D cellulose crystallizers with tunable porosity and surface properties, which achieves a state-of-the-art evaporation rate as high as  $9.8 \text{ kg m}^{-2} \text{ h}^{-1}$ ;
- Achieve Li selectivity among other co-exist ions by orders of magnitude;
- Uncover the mechanism of crystallization from both theory and simulation.

- July 2024 - Present      Technoeconomic Analysis (TEA) of Lithium Extraction from Brines
- Assess different lithium extraction process and its commercialization chance and impact;
  - Identify cost of each treatment unit for benchmark technologies for lithium extraction;
  - Sensitivity analysis to reveal key TEA indicators.
- April. 2022 - Sept. 2023      Reactive Crystallizer for Selenium Removal & Recovery
- Design wood-based reactive crystallizer for concentrating selenium wastewater and recover selenium;
  - Select best wood materials based on evaporation performance and selenium recovery efficiency;
  - Conduct field test to reveal long-term performance of wood reactive evaporators.
- Jan. 2021 - June 2024      Model Development for Solar-driven Evaporation
- Translating research project published at Nature Water (see Journal Publication [1]) to industry-level lithium extraction;
  - Develop evaporation model and climate model that could facilitate the industrial lithium production;
  - Improve the accuracy of evaporation model that help reduce error from 52.46% to 6.01%, significantly helps real operation and reduce cost;
  - Establish climate model with improved accuracy, which reduced 30% error.

### **Data-driven Modeling for Material Design and Environmental Studies**

- Aug. 2021 - Present      Machine learning (ML)-assisted Pervaporation Membrane Design for Organic Recovery
- Develop predictive ensemble models to select promising polymers from 1 million candidates for organic extraction, which overcomes the limitations of speed and cost of the traditional experimental approaches;
  - Construct a state-of-the-art PV dataset with ~3000 data points from 283 literatures;
  - Improve ML models' robustness via data leakage management;
  - Incorporate explainable ML-techniques to understand the separation mechanism of the selected membranes, assisting experimental design with data-driven evidence.
- June 2023 - Present      Advancing Environmental Studies with a Specialized Large Language Model (LLM)
- Develop the largest textbook-based Q&A dataset to date, comprising over 2,000 Q&A examples from 22 environmental textbooks, enhancing resource availability in the environmental domain;
  - Perform large-scale data analysis for knowledge synthesis from the textbook datasets;
  - Create an open-source LLM platform, specifically enriched with environmental knowledge, to support research and education in environmental studies.

### **Electrocatalytical Resource Recovery and Wastewater Treatment**

- Aug. 2020 - June 2021      Multielement Alloy Catalysts Design for Selective Electrocatalytic Nitrate Reduction (ENR) to Ammonia
- The first study that investigates the synergistic effect between multiple reaction sites on multi-elemental alloy nanoparticles for effective ENR reaction;
  - Optimize the operational parameters such as electrolyte conditions and applied potentials to achieve a high  $\text{NH}_3$  faradaic efficiency (93.5%) in industrially relevant acidic wastewater;
  - Develop a continuous flow reactor with doubled ammonia yield ( $3171.0 \mu\text{g h}^{-1} \text{cm}^{-2}$ ) compared with pure Ru catalyst.

## **PARTICIPATION IN PROPOSAL WRITING**

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- Department of Energy (DOE), reference number: DE-FOA-0003105, Opportunity: Critical Material Innovation, Efficiency, and Alternatives

## **JOURNAL PUBLICATIONS (†first author with equal contribution)**

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### **Evaporation and Crystallization for Resource Recovery**

1. **Meiqi Yang**†, Chen, Xi†, Sunxiang Zheng, Fernando Temprano-Coletto, Qi Dong, Guangming Cheng, Nan Yao, Howard A. Stone, Liangbing Hu, and Zhiyong Jason Ren. "Spatially Separated Crystallization for Selective Lithium Extraction from Saline Water." *Nature Water* (2023). (**Front Cover, Princeton News Release**)
2. Sunxiang Zheng, **Meiqi Yang**, Xi Chen, Claire E. White, Liangbing Hu, and Zhiyong Jason Ren. "Upscaling 3D Engineered Trees for Off-Grid Desalination." *Environmental science & technology* (2022). (**Top journal in environmental study field**)

### **Data-driven modeling and advanced machine learning**

3. **Meiqi Yang**, Jun-Jie Zhu, Allyson McGaughey, Rodney D. Priestley, Eric M. V. Hoek, David Jassby, Zhiyong Jason Ren "Machine Learning for Polymer Design to Enhance Pervaporation-Based Organic Recovery." *Environmental science & technology*, 2024 (**Top journal in environmental study field, front cover**)
4. **Meiqi Yang**, Jun-Jie Zhu, Allyson McGaughey, Sunxiang Zheng, Rodney D. Priestley, and Zhiyong Jason Ren. "Predicting Extraction Selectivity of Acetic Acid in Pervaporation by Machine Learning Models with Data Leakage Management." *Environmental Science & Technology* 57, no. 14 (2023): 5934-5946. (**Top journal in environmental study field**)
5. Jun-Jie Zhu, **Meiqi Yang**, and Zhiyong Jason Ren. "Machine Learning in Environmental Research: Common Pitfalls and Best Practices." *Environmental Science & Technology* (2023). (**Supplementary Cover**)
6. Jun-Jie Zhu, Jinyue Jiang, **Meiqi Yang**, and Zhiyong Jason Ren. "ChatGPT and environmental research." *Environmental Science & Technology* (2023). (**50k Article View, Most downloaded paper**)

### **Material Engineering for Wastewater Treatment, Decarbonization, and Sustainability**

7. **Meiqi Yang**, Boyang Li, Shuke Li, Qi Dong, Zhennan Huang, Sunxiang Zheng, Ying Fang et al. "Highly Selective Electrochemical Nitrate to Ammonia Conversion by Dispersed Ru in a Multielement Alloy Catalyst." *Nano Letters* (2023). (**Supplementary Cover**)
8. **Meiqi Yang**†, Xin Shen†, Chengxing He, Tianshuo Zhao, Devan Solanki, Rito Yanagi, Ben Gibbs, Gouri Krishnan, and Shu Hu. "Multicolor Bipolar Modulation of Titanium–Chromium Oxide Electrochromic Coatings." *ACS Applied Electronic Materials* 5, no. 3 (2023): 1812-1823.
9. Xiaobo Zhu, Joshua Jack, Aaron Leininger, **Meiqi Yang**, Yanhong Bian, Jonathan Lo, Wei Xiong, Nicolas Tsesmetzis, and Zhiyong Jason Ren. "Syngas mediated microbial electrosynthesis for CO<sub>2</sub> to acetate conversion using *Clostridium ljungdahlii*." *Resources, Conservation and Recycling* 184 (2022): 106395.
10. Xin Shen, Tianshuo Zhao, Haoqing Su, **Meiqi Yang**, Jiaye Chen, Yulin Liu, Rito Yanagi, Devan Solanki, and Shu Hu. "Tuning Intermediate Bands of Protective Coatings to Reach the Bulk–Recombination Limit of Stable Water–Oxidation GaP Photoanodes." *Advanced Energy Materials* 12, no. 29 (2022): 2201314.
11. Tianshuo Zhao, Rito Yanagi, Yijie Xu, Yulian He, Yuqi Song, **Meiqi Yang**, and Shu Hu. "A coating strategy to achieve effective local charge separation for photocatalytic coevolution." *Proceedings of the National Academy of Sciences* 118, no. 7 (2021): e2023552118.
12. Xuechen Zhou, Mohammad Heiranian, **Meiqi Yang**, Razi Epsztein, Kai Gong, Claire E. White, Shu Hu, Jae-Hong Kim, and Menachem Elimelech. "Selective Fluoride Transport in Subnanometer TiO<sub>2</sub> Pores." *ACS nano* 15, no. 10 (2021): 16828-16838.
13. **Meiqi Yang**, Xuefei Sun, Shuguang Wang, *Preparation of carboxymethyl chitosan-glucan composite microspheres and adsorption behavior to fluorine ion*, [J]. *Acta Scientiae Circumstantiae*, 2017, 37(12): 1-7.

## PREPRINTS

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1. **Meiqi Yang**, Fernando Temprano-Coletto, Hongxu Chen, Christopher Li, Howard A. Stone, Zhiyong Jason Ren. “Developing Novel Evaporation-based Extraction Process for Lithium Recovery from Oil and Shale Gas Brine.” *Energy & Environmental Science*. Under review
2. **Meiqi Yang**, Sunxiang Zheng, Hongxu Chen, Zhiyong Jason Ren. “Leveraging Wood Chemistry for High-Performance Selenium Recovery with Reactive Evaporator.” In submission
3. Zhou, Guangye; Li, Boyang; Cheng, Guangming; Breckner, Christian; Dean, David; **Yang, Meiqi**; Yao, Nan ; Miller, Jeffrey; Klok, Johannes; Tsesmetzis, Nicolas; Wang, Guofeng; Ren, Zhiyong Jason. “Concentrated C2+ Alcohols Production enabled by Post-Intermediate Modulation and Augmented CO Adsorption in CO Vapor Electrolysis.” *JACS*, Under review
4. Jun-Jie Zhu, **Meiqi Yang**, Jinyue Jiang and Zhiyong Jason Ren. “Cost-Accuracy Evaluation of Large Language Models for Domain-Specific Question-Answering.” *ES&T Letters*. Under review

## UNDER PREPARATION

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1. **Meiqi Yang**, Kaijie Yang, Hongxu Chen, Sunxiang Zheng, Zhiyong Jason Ren “Mechanism Understanding of Selective Crystallization with Surface Functionalization and Potential for Mineral Extraction.”
2. Kaijie Yang, **Meiqi Yang**, Hongxu Chen, Sunxiang Zheng, Zhiyong Jason Ren “Leveraging Solar Energy to Revolutionize Brine Mining.”
3. Sidan Lu, **Meiqi Yang**, Xinyi Wang, Fernando Temprano-Coletto, David Jassby, Eric Hoek, Zhiyong Ren. “Conductive fabric distillation for interfacial clean water production.” Under preparation

## CONFERENCE & PRESENTATION

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- Environmental Domain-Specific Large Language Models for Expert-Level Closed-Book Question-Answering, *American Chemical Society*, Denver, 18 August, 2024, poster presentation
- Towards an environmentally just transition: the future of lithium mining, *Princeton Energy & Climate Scholars (PECS) & Princeton High Meadows Environmental Institute (HMEI)*, 2024, invited panelist
- New material for selective and effective lithium extraction from saline water, *American Chemical Society*, New Orleans, 18 March, 2024, poster presentation
- Machine learning for polymer design to enhance pervaporation-based organic recovery, *American Chemical Society*, New Orleans, 19 March, 2024, oral presentation
- Leveraging Wood Chemistry for High-Performance Selenium Recovery with Reactive Evaporator, *Association of Environmental Engineering and Science Professors*, Boston, 20 June, 2023, oral presentation
- Spatially Separated Crystallization for Selective Lithium Extraction from Saline Water, *Materials Imaging Workshop*, 3 November, 2023, invited oral presentation
- Enhancing Pervaporation-based Organic Recovery through Machine Learning-Assisted Polymer Design, *Association of Environmental Engineering and Science Professors*, Boston, 20 June, 2023, poster presentation
- Accelerated Lithium Extraction from Brines with Interfacial Evaporation, *American Geophysical Union Conference*, Chicago, 12 December, 2022, poster presentation
- Highly Selective Electrochemical Nitrate to Ammonia Conversion in Acidic Industrial Wastewater Condition by Dispersed Ru in a Multielement Alloy Catalyst, *Andlinger Center for Energy and the Environment Annual Meeting*, Princeton, 14 October, 2022, poster presentation
- Preparation of carboxymethyl Chitosan Microspheres and the Adsorption of Heavy Metal Cadmium, *International Conference on Innovative Material Science and Technology*, IMST 2016, 305-313.

## **PATENTS**

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- **Meiqi Yang**, a *Fluorine-Containing Wastewater Treatment Plant*. **Certificate of Utility Model Patent: ZL 201720239707.7**

## **JOURNAL REVIEWER**

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- Environmental Science and Technology, Environmental Science Nano, Analytical Chemistry, Patterns, Sensors & Diagnostics

## **TEACHING & MENTORSHIP**

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- Linda Zeng, The Harker Upper School, California, High School Student, June - July 2024
- Christopher Li, Princeton University, Sophomore, Feb. - May 2024
- Ryan Neapole, Princeton University, Undergrad Thesis, now at Stanford University, Feb. - May 2023
- Qixiang Feng, Princeton International School of Mathematics and Science, High School Student, June - Aug. 2023
- Siyu (Quinn) Li, Dwight-Englewood School, High School Student, now at University of Pennsylvania, 2022
- ENE321-CEE321\_F2021 Resource Recovery for a Circular Economy, Teaching Assistant, 2021 Fall
- Gouri Krishnan, King School in Stamford, High School Student, now at Columbia University, 2019

## **SKILLS**

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- **Software:** Pytorch, Python, UNIQUAC, COMSOL, FDTD, Avizo, Athena, Artemis, AutoCAD
- **Instrumental Operation:** X-ray photoelectron spectroscopy (XPS), X-ray powder diffraction (XRD), Scanning/Transmission Electron Microscope (S/TEM), Atomic Layer Deposition (ALD), Scanning electron microscope (SEM), UV-Vis-DRS, Ellipsometry, Electrochemical Impedance Spectroscopy (EIS), and 3D X-ray tomography Microscope, etc.

## **REFERENCE**

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*Zhiyong Jason Ren*, [zjren@princeton.edu](mailto:zjren@princeton.edu).

Professor of Civil and Environmental Engineering and the Andlinger Center for Energy and the Environment, Associate Director for Research, Andlinger Center for Energy and the Environment, Princeton University

*Howard A. Stone*, [hastone@princeton.edu](mailto:hastone@princeton.edu).

Donald R. Dixon '69 and Elizabeth W. Dixon Professor, Princeton University

*Menachem Elimelech*, [menachem.elimelech@yale.edu](mailto:menachem.elimelech@yale.edu).

Sterling Professor of Chemical and Environmental Engineering, Yale University