CHEMICAL ENGINEERING

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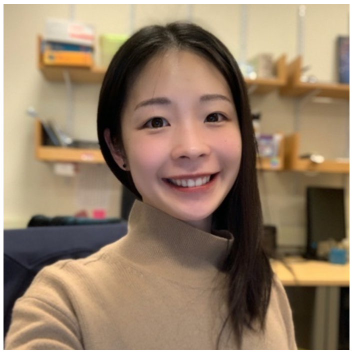

YAYUAN LIU

Monday, August 3, 2020

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Massachusetts Institute of Technology

Materials Design and Electrochemical Engineering at the Energy-Environment Nexus: from High Energy Density Battery to Carbon Capture

ABSTRACT: The energy-environment nexus is critical as strategies to meet the growing worldwide energy demand are developed. To ensure sustainable growth and development, energy productions must have minimal environmental impact. In the short term, fossil fuels will remain dominant such that efficient carbon capture technology is a priority for conventional power generation. In the long term, renewable energies need to be adopted, which requires high-capacity energy storage units to compensate for their intermittent nature.

In the first part of my talk, I will describe our efforts in tackling the challenges of metallic lithium anode, which is the ultimate battery chemistry due to its highest theoretical capacity. I will discuss the failure mechanisms of lithium metal, especially the key role of infinite relative volume change which has long been overlooked by the community[1]. Upon the understandings, rational material designs for constructing three-dimensional lithium metal composites have been developed (*Figure 1a*), which demonstrated

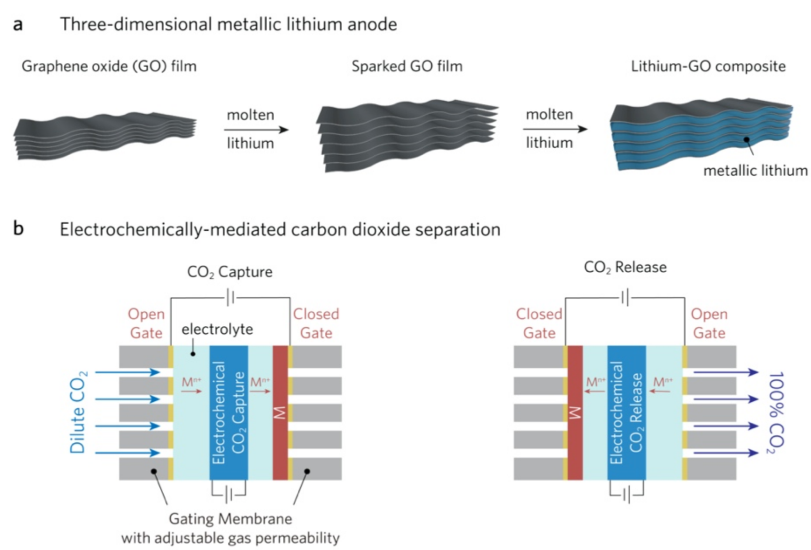

Figure 1. (a) Fabrication of three-dimensional composite lithium metal anode via a molten lithium infusion method.

significantly improved stability and electrochemical performance[2,3].

In the second part of my talk, an electrochemically-mediated carbon capture technique will be introduced, which relies on redox-active compounds that undergo changes in their carbon dioxide binding affinity as they progress through an electrochemical cycle[4]. Compared to conventional amine scrubbing, this process can be more energy-efficient and is easier to implement by retrofitting existing infrastructure. By leveraging the electrolyte formulation, the process can be carried out with high reversibility in aqueous solutions. Through integration with a novel gas-gating membrane that dynamically controls gas passage, an effectively continuous operation of carbon capture and release can be achieved for process intensification, bringing new opportunities to acid gas separation (*Figure 1b*)[5].

Overall, the goal of my research is to integrate precisely-controlled materials synthesis, electrochemical engineering and advanced characterization techniques to accelerate our society's transition into a more sustainable energy landscape.

BIOGRAPHY: Yayuan Liu earned her Ph.D. in 2019 from Stanford University under the supervision of Prof. Yi Cui in the department of Materials Science and Engineering. During her graduate study, she pioneered a series of materials design methodologies to tackle the challenges of lithium metal anode for next-generation batteries, and fundamentally correlated the physicochemical properties of the electrode-electrolyte interface with lithium deposition behavior using advanced characterization techniques. Yayuan is currently a Postdoctoral Associate at the Massachusetts Institute of Technology, working with Prof. T. Alan Hatton in the department of Chemical Engineering. She is developing redox-active sorbents and stimuli-responsive gas gating membranes for electrochemically-mediated carbon dioxide separation. Yayuan has received multiple awards for her research, including the ACS Division of Inorganic Chemistry Young Investigator Award in 2019, the MRS Graduate Student Gold Award in 2018 and the Stanford Graduate Fellowship. Yayuan is also passionate about science communication and is a MIT Chemical Engineering Communication Lab Fellow.

LECTURE 1:00 - 2:00 Zoom
Networking Hour on Zoom Following

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[1] Reviving the lithium metal anode for high-energy batteries. *Nat. Nanotechnol.* 12, 194-206 (2017).
[2] Layered reduced graphene oxide with nanoscale interlayer gaps as a stable host for lithium metal anodes. *Nat. Nanotechnol.* 11, 626-632 (2016).
[3] Lithium-coated polymeric matrix as a minimum volume-change and dendrite-free lithium metal anode. *Nat. Commun.* 7, 10992 (2016).
[4] Electrochemically-mediated gating membrane with dynamically-controllable gas transport. *submitted*
[5] Electrochemically-mediated carbon dioxide separation with quinone chemistry in salt-concentrated aqueous media. *Nat. Commun.* 11, 2278 (2020).