ADVERTISEMENT FEATURE

UNLEASHING THE POTENTIAL OF BATTERIES AND ENERGY STORAGE

A CONVERSATION WITH SHIRLEY MENG, Liew Family Professor at the Pritzker School of Molecular Engineering, University of Chicago.

As the demand for sustainable energy grows, improving battery performance is crucial. By freezing moments of change during battery operation, Shirley Meng, and her colleagues at the University of Chicago, uncover the intricacies of atomic and molecular interactions. This insight helps them refine materials for advanced batteries and energy storage systems. Leading the Laboratory for Energy Storage and Conversion, Meng's research is advancing the development of better battery materials. Here, she discusses her innovative work and key moments in her career.

What inspired you to become a molecular engineer?

As a child, I was intrigued and fascinated by how metal objects could be made to fly; how planes are built to withstand extraordinary forces and strong enough to carry hundreds of people across oceans. Originally, I'd hoped to become an aeronautical engineer after my undergrad, but that didn't work out. Instead, I interned on superconductors and became interested in techniques for exploring the properties of materials. For my PhD, I combined first principles computational methods to determine what could replace cobalt in first generation lithium-ion batteries. I'd like to think that both aviation and batteries will feature in my future — perhaps we could create electric flying cars within my lifetime.

What are your lab's main goals?

Essentially, we're doctors for batteries. We pinpoint failure modes at the atomic and molecular level so that we can prescribe better engineering mitigation strategies and improve battery performance. We research all kinds of different batteries, from miniature batteries for the Internet of Things and cell phones, to lithium-ion and lithium metal batteries for mobility and transportation. In the next decade, we'll focus on Earth abundant materials and batteries for grid scale storage.

What technologies support your research?

I use scanning electron microscopy and spectroscopy techniques to examine the intricacies of material behaviours. First principles calculations, which use quantum mechanics, help us predict material properties, meaning we can screen multiple potential materials without synthesizing them all from scratch. We then fabricate and conduct extensive studies on the most promising materials.

Even as a mid-career researcher, I find it astonishing that we can now visualize interacting materials at the molecular level under realistic operating conditions. These technologies will help resolve real-world problems, not just for biological and medical studies, but in materials science and molecular engineering too.

"ESSENTIALLY, WE'RE DOCTORS FOR BATTERIES"

Describe a moment in your lab that took you by surprise.

Since 2016 my group has been developing cryogenic electron microscopy (CEM) for battery analysis. Batteries are inherently very reactive, that's what makes them so powerful. The ions moving around inside the battery induce dynamic structural, chemical and phase changes: the ability to freeze these states and take a closer look at them is invaluable. It allows us to see what's happening at the interface between the electrode and electrolyte, or on the surface of the reactive lithium metal.

We were genuinely shocked when we first looked at lithium metal batteries using CEM. These batteries could only achieve around 200 charging cycles and were plagued with inefficiency issues, but nobody knew why. We discovered that most of the lithium metal was effectively 'dead' in the cell after repeated cycles, because they were wrapped around by insulating materials. They were still metallic, but their activity was lost. Lithium metal batteries can now achieve more than 1,000 cycles thanks to our discovery.

Have any obstacles led you to other key discoveries?

Batteries are as temperamental as human bodies; for example, they don't perform well at low temperatures. We pioneered the design of a liquefied gas electrolyte based on difluoromethane[1], which enabled us to create lithium batteries that operate at a wide temperature range of -78ºC to +65ºC. This discovery led to a spin-off company called South 8 Technologies, founded by my graduate students, whose products made it into the Time magazine's best inventions list 2024. I'm so proud of this achievement.

We also developed a lithium-ion battery with pure silicon anodes and a sulphide-based solid-state electrolyte (SSE). Unlike traditional silicon-carbon anodes, our pure silicon anodes prevent SSE decomposition, extending battery life. The SSE also stops silicon from cracking, a common issue with liquid electrolytes. This breakthrough significantly advances the field.

▲ Shirley Meng's lab is advancing sustainable energy with innovative battery materials and cutting-edge research at the atomic level.

da-kuk/ Getty Images

What challenges are shaping your research?

Batteries are not renewable. Their production consumes vast amounts of materials and energy, and not all components are recyclable. Politicians and policymakers must understand the need for terawatt-hour storage batteries to achieve the energy transition. We require alternative, abundant materials for these batteries, and investment in these solutions is crucial. Science as a concept has no boundaries, and we do not lack brilliant minds or creative talent. Yet scientists are restricted within set boundaries, most often by geopolitical forces. International cooperation, open-source knowledge and data sharing are paramount to achieving an effective and sustainable global energy transition. ■

REFERENCES

1. Rustomji, C.S. *et al. Science* **356:** 6345 (2017) DOI: 10.1126/science.aal4263
2. Tan, D.H.S. *et al. Science* **373:** 6562 (2021) DOI: 10.1126/science.abg7217