

Batteries & Supercaps: Making a Better Tomorrow

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What is our Research Focus?

The research interests in the Key Laboratory of Advanced Energy Materials Chemistry (AEMC) cover energy storage and conversion (Figure 1), ranging from hydrogen/carbon dioxide storage to electrocatalysis and different types of batteries, solar cells, and fuel cells. In our group, we focus on the rational design and controllable synthesis of inorganic (e.g., 3d transition metal oxides and sulfides) and organic (e.g., quinone compounds) electrode materials. Examples include the selective preparation of nanocrystalline spinels at near room temperature through 'redox-conversion-crystallization' methodologies and the green synthesis of calix[4]quinone from biomass resources. By combining DFT computations and in-situ characterization techniques such as Raman, FTIR, AFM, and XRD, efforts are also dedicated to the understanding of the surface/interface chemistry, reaction mechanisms and the structure-property relationship of electrode materials.

Why is Energy Materials Chemistry so Important, what are the Major Issues and Future Perspectives?

Today, we face increasing environmental and climate problems due to the global consumption of fossil fuels, such as coal, oil, and natural gas. To address the challenges, we must develop

clean and renewable energy technologies and shift to electrified transportation. In this context, there is a tremendous demand for electrochemical devices, such as batteries and supercapacitors that are suitable for applications in large scale energy storage and electric vehicles. Meanwhile, the vast development of portable electronics as well as the emerging fields of artificial intelligence and the Internet of things strongly rely on smart power. However, current electrochemical energy storage and conversion technologies cannot meet the requirements of high energy/power density, high energy conversion efficiency, long cycle life, low cost, and high safety. For most batteries and fuel cells, there is still much room for improvement to narrow the gap between practical and theoretical performance by key material modification and system optimization.

To build better batteries and supercapacitors, we need to exploit new electrode materials and other electrochemically inactive, yet functional components, including electrolytes, separators, binders, conducting additives, current collector, etc. A few selective examples from our group to mention here are Li-rich cathode materials, organic quinone-derivative materials, Si/C nanocomposite anodes, rGO-protected Li/Na anodes, and Co-Mn spinel oxides as electrocatalysts. It is desirable to understand redox reactions, electron transfer, ionic diffusion, and compositional/structural evolution at different levels from atomic scaleup to the device dimension. Moreover, properties of surface and interface at electrodes and electrolytes are very important in determining the reactivity, kinetics, and stability of electrochemical systems. Rational design and tailoring advanced energy materials may resort to breakthrough in in-situ and operando techniques with high spatial and temporal resolution. Progress in DFT calculation and other multiscale modelling methods will also advance the science of energy materials chemistry.

What should we Teach Students in Energy Materials Chemistry Courses?

Energy materials chemistry is a multidisciplinary field. We expect our students to gain a broad spectrum of knowledge and training in Chemistry, Physics, Mathematics, Materials Science, and Metallurgical Engineering. In our department, we are going to set up a new major, namely, Renewable Energy Science and Engineering. Specifically, we plan to teach specialized courses on energy storage and conversion, chemical power sources, solar cell science and technology, electrochemistry, microscopy, metallurgy, materials physics, solid-state chemistry, surface science, catalysis science, internet of energy and intelligent energy management science, in addition to liberal art and elementary major courses.

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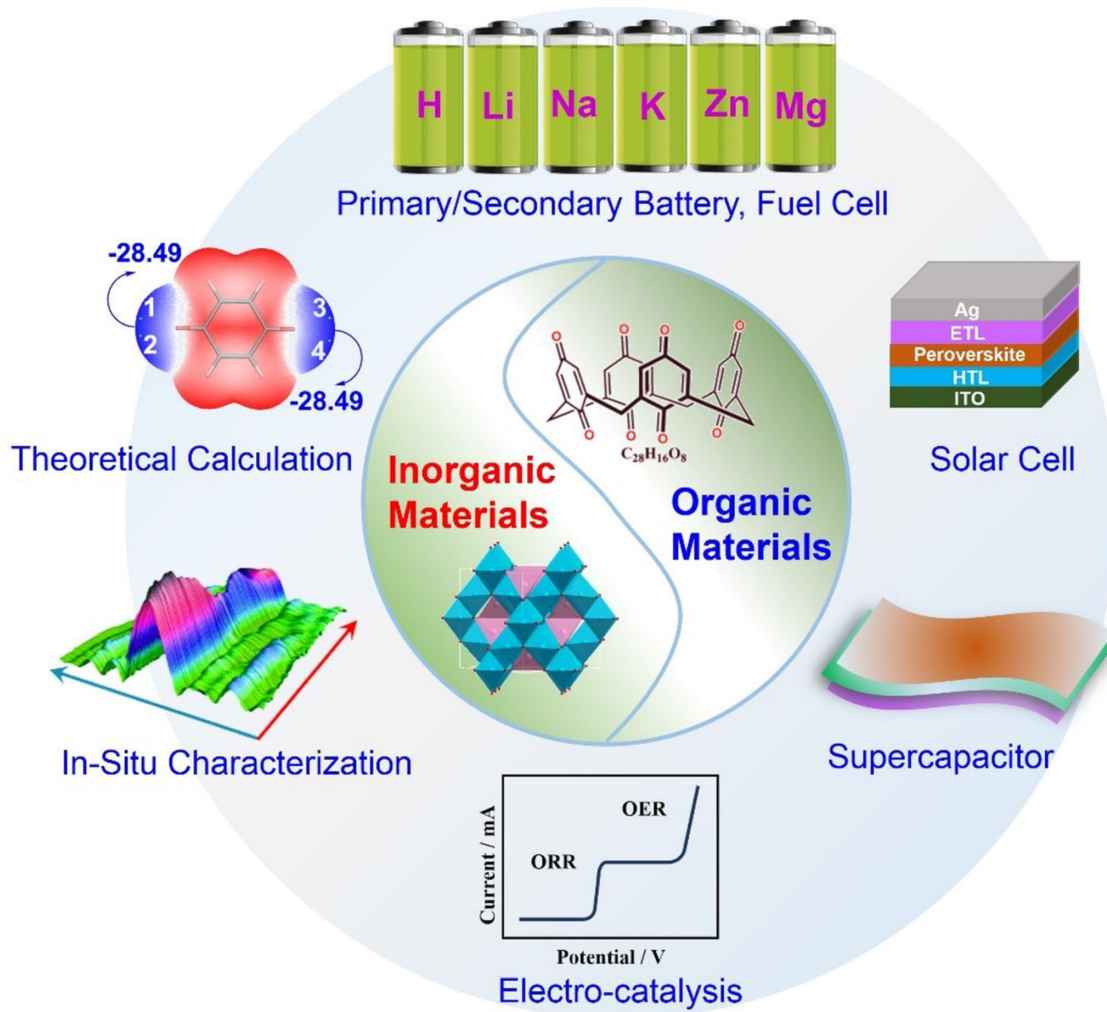


Figure 1. The main research interests of our group.