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Education:

B.S.	Fudan University	1996 -2000
M.S.	Fudan University	2000 - 2003
Ph.D.	UCLA	2003 - 2008

Employment History:

Professor, University of Houston	2020.9.1 -
Associate Professor, University of Houston	2017 - 2020
Assistant Professor, University of Houston	2012 - 2017
Postdoc, Stanford University	2010 - 2012
Senior Scientist, Polyera Corp.	2008 - 2010

Honors and Awards:

- Fellow, Royal Chemical Society (UK) (2020)
- Senior Member, National Academy of Inventors (2020)
- Cullen College of Engineering Professorship (2020)
- Emerging Investigators in Electrochemical Energy Conversion and Storage - Journal of Electrochemical Energy Conversion and Storage (2020)
- Senior Member, IEEE (2019)
- Highly Cited Researchers List (Top 1% by citations) - Clarivate Analytics, 2018
- Office of Naval Research Young Investigator Award - U.S. Office of Naval Research, 2013
- Principal Investigator - U.S. Advanced Research Projects Agency-Energy, 2013
- Award for Excellence in Research, Scholarship, or Creative Activity at the Associate Professor Level - University of Houston, 2018
- Scialog Collaborative Innovation Award - Research Corporation for Science Advancement, 2018
- Scialog Fellow on Advanced Energy Storage - Research Corporation, 2017
- Junior Faculty Research Excellence Award - University of Houston, Cullen College of Engineering, 2016
- Teaching Excellence Award - University of Houston, Cullen College of Engineering, 2016
- TcSUH Welch Foundation Professorship Award - Welch Foundation, 2012
- Ralph E. Powe Junior Faculty Enhancement Award - Oak Ridge Associated Universities, 2013

Recent Research Highlights:

- Quinone electrodes for long cycle-life aqueous batteries: Aqueous electrolytes are low-cost, high conductivity, and environmental benign. However, aqueous batteries generally show poor cycle life, limited by the structural and chemical instability of anode materials. In our study funded by APRA-E RANGE program, we designed and synthesized three quinone molecule and polymers that are stable in a broad pH range with unprecedented long cycle life of 3000 cycles. Three battery systems with the quinone anodes coupling with industrially established cathodes and electrolytes have been demonstrated with state-of-art specific energy/energy density. (Nature Materials 2017 and highlighted in Nature Energy 2017). The paper has been cited over 117 times. A team of UH business/engineering students won the first place in the UNL New Venture business plan competition based on these inventions. We also reported an aqueous Ca-ion battery for the first time (Advanced Science 2017).

- Dendrite-free Mg rechargeable batteries: Mg rechargeable batteries represent a safe and high-energy battery technology but lack an efficient Mg-ion cathode. In the Office of Naval Research funded project, we demonstrated an atomic-level lattice tuning to expand interlayer spacing of two-dimensional materials such as MoS_2 and TiS_2. The expansion enables the otherwise barely active MoS_2 to approach its theoretical storage capacity. (Nano Lett. 2015, cited 147 times) An in-situ expanded TiS_2 can improve the specific capacity to 400 mAh/g. Using a combined theoretical modeling and spectroscopic analysis, we reveal fast kinetics of $MgCl^+$ insertion TiS_2 without scission of magnesium chloride bond (Nature Comm. 2017, cited 47 times). This work was highlighted on the DOE Office of Science website. Using organic redox polymers as an example, we recently clarified the importance of Mg electrolyte chemistry on cell-level energy storage (Joule 2019). We critically reviewed the promises and reality of multivalent-ion batteries (Nature Energy 2020, in press).

- Organic redox materials for energy storage: In 2015, my group first showed "π-conjugated redox polymers" that simultaneously feature a π-conjugated backbone and redox sites can function as a light-weight material for ultrafast energy storage. The polymer delivers 95% of its theoretical capacity at a high rate of 100C (72 s per charge−discharge cycle) as well as 96% capacity retention after 3,000 cycles of deep discharge−charge. This work (JACS 2015, cited 99 times) was selected as Editor's Choice and JACS Spotlight. Extending this work to cross-conjugated oligomeric quinones maintains high rate performance but also significantly enhances the specific capacity (Nano Energy 2017). Utilizing EQCM-D, NMR, and in-situ conductivity measurement, we are investigating how organic crystals and polymers interact with ions, solvents and the reaction intermediates and reaction pathways. The improved molecular insights into these reactions point to the ion-coordination mechanism, rather than the bond-breaking and formation mechanism, as the rate-determining process. To compare organic electrode materials with inorganic materials in the battery landscape, we thoroughly analyzed charge storage mechanism, working potential, specific capacity, resource availability, and we point out future research directions of organic redox materials (Joule 2019, Chem Rev. 2020).

- Solid-state batteries: We report two high-capacity organic cathode materials Na4C6O6 and PTO that form reversible active material-electrolyte interfacial resistance evolution and intimate physical contact during battery cycling. (Angewandte Chemie 2018; Joule 2019). The performance deterioration of a solid-state Li battery is the result of a combination of interfacial events. Characterization of these interfaces has been an ongoing challenge, and solid-state batteries are considered by some as a "black box". In our recent awarded DOE VTO project, we will develop a platform combining for structural, chemical, and mechanical characterizations using FIB-SEM tomography, ToF-SIMS, and in-SEM nanoindentation to produce multidimensional understandings of interface evolutions in solid-state batteries.

Lab Facilities / Expertise:

The Yao Group research focues on the intersection of materials chemistry and electrochemical energy storage, with an overarching goal to understand the mechanisms and challenges of current battery technologies. Current research projects include lithium metal batteries, multivalent-ion batteries, organic electrode materials, diagnostic tools for operando solid-state batteries, electrocatalysts for CO_2 reduction, Li-CO_2 batteries, and CO_2 removal from sea water.

Five Selected Publications:

1. Y. Liang, H. Dong, D. Aurbach*, and Y. Yao*, Current status and future directions of multivalent-ion batteries, *Nature Energy* 2020, in press.
2. Fang Hao, Xiaowei Chi, Yanliang Liang, Ye Zhang, Rong Xu, Hua Guo, Tanguy Terlier, Hui Dong, Kejie Zhao,

Jun Lou, and Yan Yao*, Taming active material-solid electrolyte interfaces with organic cathode for all-solid-state batteries, *Joule* 2019, 3, 1349-1359.

3. Tailored organic electrode material compatible with sulfide electrolyte for stable all-solid-state sodium batteries
Xiaowei Chi, Yanliang Liang, Fang Hao, Ye Zhang, Justin Whiteley, Hui Dong, Pu Hu, Sehee Lee, Yan Yao*, *Angewandte Chemie* 2018, 130, 2660-2264.

4. Yanliang Liang, Yan Jing, Saman Gheytani, Kuan-Yi Lee, Ping Liu, Antonio Facchetti*, Yan Yao*, Universal quinone electrodes for long cycle life aqueous rechargeable batteries*, Nature Materials* 2017, 16, 841.

5. Hyun Deog Yoo, Yanliang Liang, Hui Dong, Junhao Lin, Hua Wang, Yisheng Liu, Lu Ma, Tianpin Wu, Yifei Li, Qiang Ru, Yan Jing, Qinyou An, Wu Zhou, Jinghua Guo, Jun Lu, Sokrates T. Pantelides, Xiaofeng Qian & Yan Yao*, Fast kinetics of magnesium monochloride cations in interlayer-expanded titanium disulfide for magnesium rechargeable batteries, *Nature Communications* 2017, 8, 339.