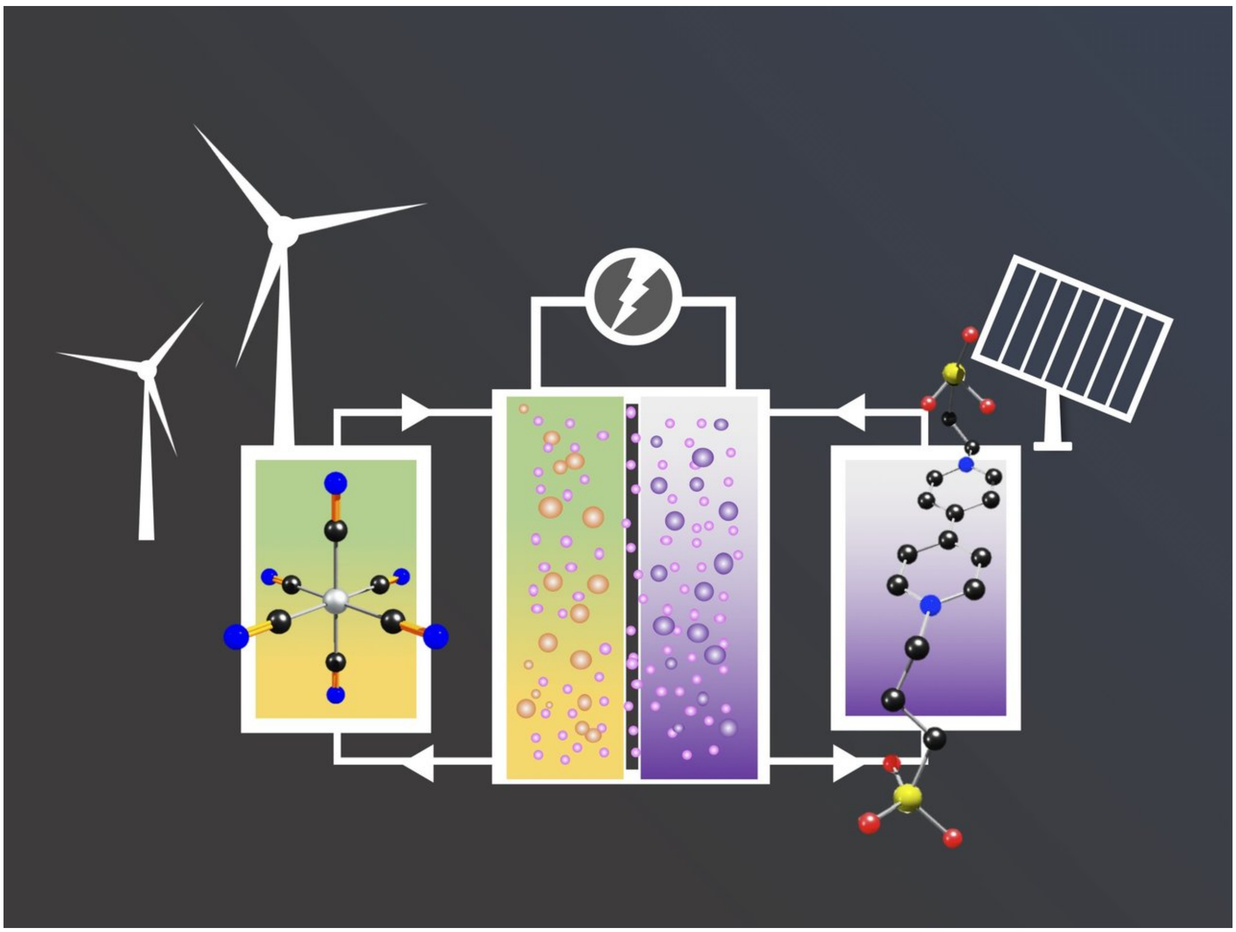
Simple change, big impact: Chemists advance sustainable battery technology

October 25 2018, by Mary-Ann Muffoletto



Utah State University's Liu Chemistry Lab reports a strategy that boosts aqueous organic redox flow battery capacity, safety and performance with a simple design tweak. The design breakthrough advances energy storage capabilities for wind and solar power. Credit: Tianbiao Liu

Solar and wind energy are widely regarded as sustainable, environmentally friendly alternatives to fossil fuels, but each is only intermittently available. Both solutions need affordable, high performance energy storage technologies to be considered for widespread, reliable use.

Aqueous organic redox flow batteries, known as "AORFBs," offer a promising large-scale energy storage solution, but still have limitations. In a molecular engineering study published online October 25, 2018, in *Joule*, Utah State University chemists report advances to address these limitations.

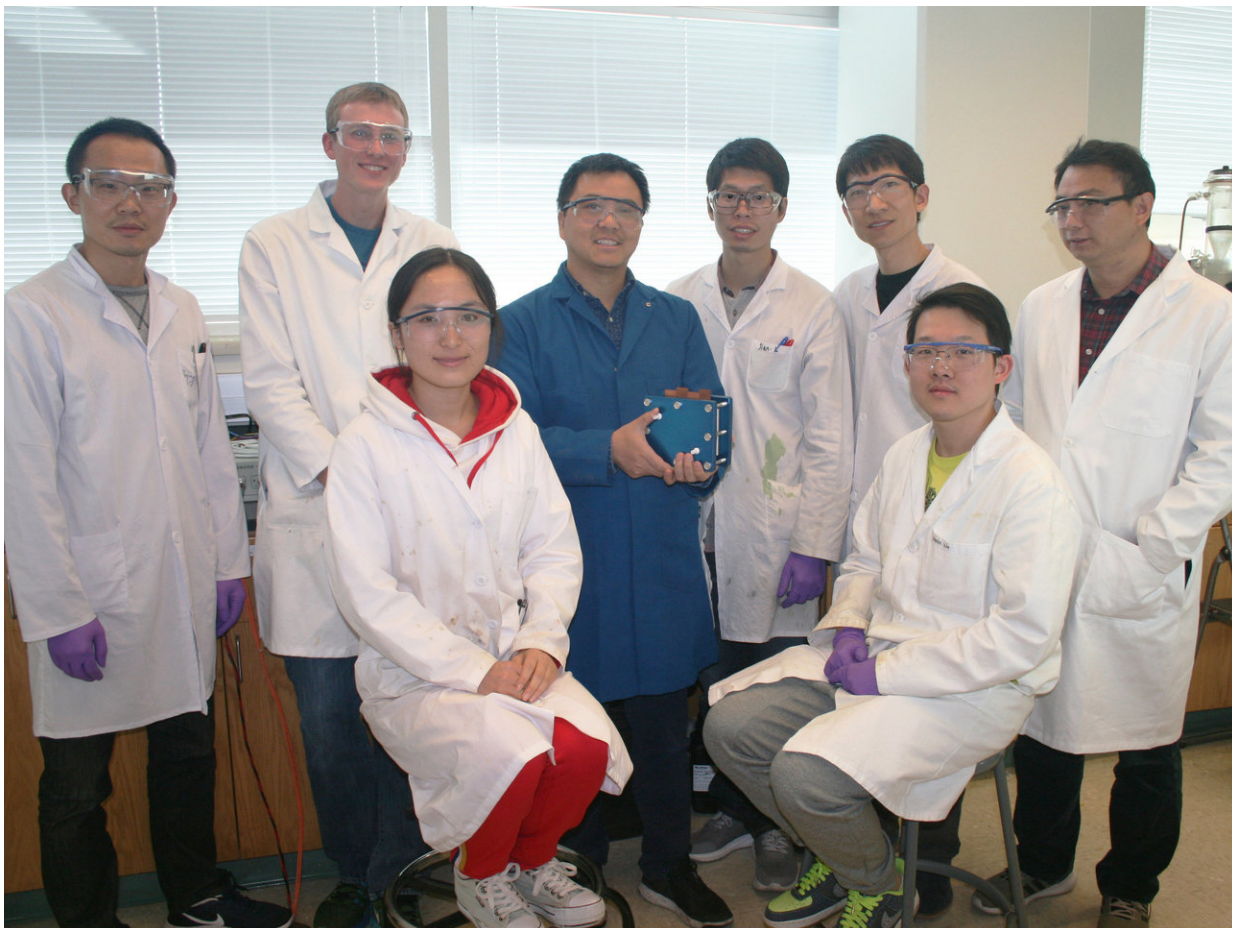
USU postdoctoral researcher Jian Lu and doctoral student Bo Hu, lead authors of the paper, with graduate students Camden DeBruler, Yujing Bi, Yu Zhao, Bing Yuan, Maowei Hu and Wenda Wu and faculty advisor Tianbiao (Leo) Liu, corresponding author, and with colleagues from the Ocean University of China and Qingdao University of Science and Technology, report a strategy that boosts AORFB storage capacity, safety and performance with a simple design tweak.

The team's research is supported by USU and a Utah Science Technology and Research (USTAR) Initiative University Technology Acceleration Grant (UTAG).

"We previously found that $K_4[Fe(CN)_6]$ is chemically stable in pH neutral solution, but not in alkaline solutions," says Liu, assistant professor in USU's Department of Chemistry and Biochemistry. "However, the relative low solubility of $K_4[Fe(CN)_6]$ (0.76 M) is a challenge for flow battery applications."

In this paper, he says, the team reports a simple formula substitution that significantly improves the solubility of the potassium ferrocyanide, $K_4[Fe(CN)_6]$, by replacing the potassium cations (K^+) with more hydrophilic ammonium ions (NH_4^+).

"The newly designed $(NH_4)_4[Fe(CN)_6]$ as a cathode electrolyte can achieve a high solubility of 1.6 M in water, twice as that of $K_4[Fe(CN)_6]$." Lius says. "In addition, $(NH_4)_4[Fe(CN)_6]$, with its high solubility, also displays much higher conductivity, which increases energy efficiency and power performance for flow batteries."



Members of Utah State University Chemistry and Biochemistry’s Liu Lab report advances in sustainable battery design in the journal ‘Joule.’ Their research is supported by a Utah Science Technology Research Initiative (USTAR) University Technology Acceleration Grant. Credit: Mary-Ann Muffoletto

Moreover, he says, the team found the charge transfer, using ammonium, is faster than potassium, which further enhances the batteries' energy efficiency and power performance. When paired with a viologen anode electrolyte called (SPr)2V, a process on which the team recently published, a 24.1 Wh/L $(NH_4)_4[Fe(CN)_6]/(SPr)_2V$ flow battery delivered unprecedented cycling stability for 1000 cycles, representing the most stable flow battery known to date.

"This battery also delivered a high power density of 72.5 mW/cm^2." Liu says. "With its low cost materials, this high-performance flow battery is highly attractive for practical energy storage applications."

More information: Jian Lu; Hu, Bo; Debruler, Camden; Bi, Yujing; Zhao, Yu; Yuan, Bing; Hu, Maowei; Wu, Wenda; and Liu, Tianbiao (Leo). "Unprecedented Storage Capacity and Cycling Stability of Ammonium Ferrocyanide Catholyte Material in pH Neutral Aqueous Redox Flow Batteries." *Joule*, 25 October 2018. DOI: 10.1016/j.joule.2018.10.010

Provided by Utah State University