Materials Engineering Program

Texas Center for Superconductivity at the University of Houston

Center for Integrated Bio and Nano Systems

Enabling Ambient Sodium Sulfur Batteries

January 19, 2024

In Person Only, 1:00 – 2:00 pm

Houston Science Center (HSC), Rm.102

Dr. Rachel Carter

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Abstract: Sodium and sulfur are globally abundant, inexpensive materials with high theoretical energy density (3X Li-ion by mass and 4X by volume). However, operation of sodium-sulfur batteries in ambient conditions is not realized due to its complex, multistep conversion reaction. In order to better understand the fundamental mechanisms of the reaction, we utilize unique in-situ spectroscopy and optical microscopy. Next, to identify the proper media for the reaction to occur reliably in ambient conditions, we isolate the cathode and anode reactions, to simplify the system complexity and stabilize each component. On the sulfur cathode side, we investigate highly tailorable carbon nanofoam papers (CNFPs) to (1) host active sulfur material, (2) transport electrical current and (3) accommodate the volume expansion of the conversion reaction.[1] We also explore selenium doping to enhance electrical conductivity while participating in electrochemical conversion. At the sodium anode, we investigate plating and stripping behaviors[2] and identify distinct behaviors from its alkaline neighbor, lithium. Based on these observations we are using DFT calculations, cyclic voltammetry, Ultrafast spectroscopy, and NMR examine sodium deposition at various length and time scales. Building on our findings at each electrode, we hope to enable a functioning ambient sodium-sulfur battery.

1. Neale, Z.G.; Lefler, M.J.; Long, J.W.; Rolison, D.R.; Sassin, M.B.; Carter, R.; Freestanding Carbon Nanofoam Papers with Tunable Porosity as Lithium-Sulfur Battery Cathodes. *Nanoscale*, **2023**, DOI: 10.1039/D3NR02699J.
2. Sarkar, S.; Lefler, M.J.; Vishnugopi, B. Nuwayhid, R.B.; Love, C.T.; Carter. R.; Mukherjee, P.P.; Fluorinated ethylene carbonate as additive to glyme electrolytes for robust sodium solid electrolyte interface. *Cell Reports Physical Science*, **2023**, 4, 101356.

Bio: Rachel Carter is Research Mechanical Engineer at the U.S. Naval Research Laboratory (NRL). Prior to this role she has held the positions Karles Distinguished Scholar Fellow and National Research Council postdoctoral fellow at NRL. In fall of 2019 she was awarded the MRS Postdoctoral Award. Rachel received her Ph.D. in mechanical engineering from Vanderbilt University in 2017. Her dissertation research focused on material and processing challenges for alkali-sulfur batteries, which boast 6X the energy of Li-ion with lower cost and more environmentally friendly materials.

At NRL Rachel continues to work on sulfur chemistries, while also focusing on safer and more effective uses of conventional Li-ion batteries. In her 9 years as an energy storage researcher, she has published 61 peer-reviewed articles (h-index 34, i10-index 50) and obtained 3 patents. In 2019 Rachel was recognized by Nature as a top 5 emerging material scientist. In efforts to support women in STEM, Rachel was a co-founder of the Partnership of Women across the Naval Research Enterprise and has had the opportunity to mentor many young female researchers from the high school to graduate level.