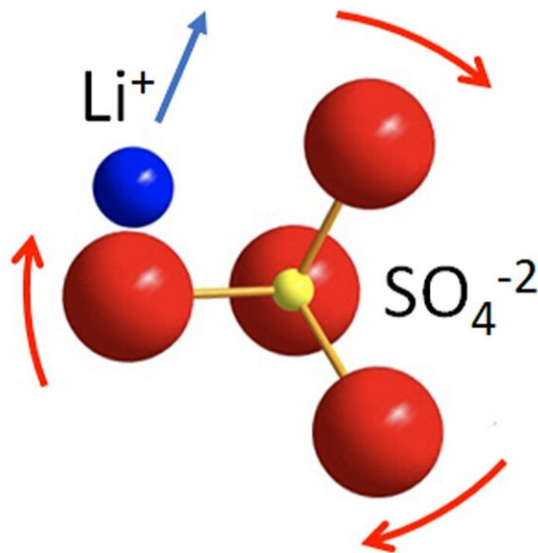


# JCESR lays foundation for safer, longer-lasting batteries

June 4 2020, by Anna Marie Tomczyk

---



The Paddlewheel Effect. Above a certain temperature,  $\text{SO}_4^{2-}$  anions begins to rotate, and simultaneously nearby  $\text{Li}^+$  cations become highly mobile. Linda Nazar's work shows that in certain solid electrolytes, altering the chemical composition enables anion rotation and the paddlewheel effect below room temperature. Credit: Argonne National Laboratory

Electricity storage in batteries is in ever increasing demand for smartphones, laptops, cars and the power grid. Solid-state batteries are

among the most promising next-generation technologies because they offer a higher level of safety and potentially longer life.

The Joint Center for Energy Storage Research (JCESR) has made significant strides with [solid-state batteries](#) as successors to today's [lithium-ion](#) (Li-ion) batteries. A major challenge with solid-state batteries is increasing the diffusivity of Li-ions in the solid-state electrolyte, which is typically slower than in the liquid organic electrolytes now used in Li-ion batteries.

JCESR's Linda Nazar, a leading professor at the University of Waterloo, and Zhizhen Zhang, her postdoctoral research associate, published their research on enhancing the mobility of Li-ions in solid-state batteries using the paddlewheel effect, which is the coordinated motion of atoms, in a paper entitled: "Targeting Superionic Conductivity at Room Temperature by Turning on Anion Rotation in Fast Ion Conductors" on June 3 in *Matter*, a monthly journal of materials science. JCESR is an Energy Innovation Hub led by the U.S. Department of Energy's (DOE) Argonne National Laboratory. The University of Waterloo is one of JCESR's 18 partners.

Solid-state batteries, using solid electrolytes in place of the usual liquid organic electrolytes, have emerged as a promising replacements for today's Li-ion batteries, according to Nazar.

"They offer the potential of safer and longer-lasting batteries that can deliver higher energy density important to a wide variety of electrochemical energy storage applications, such as vehicles, robots, drones and more," said Nazar. "As the most important component in solid-state batteries, the solid electrolyte determines its safety and cycle stability to a large extent."

An unwanted chemical reaction, called the thermal runaway reaction, has

led to fires and explosions involving today's Li-ion batteries which continue to burn until they run out of fuel. Because of these hazards, JCESR seeks to eliminate the internal liquid organic electrolyte by replacing it with a solid.

Very few solid-state electrolytes have ion conductivity as high as liquid organic electrolytes, and they receive the lion's share of attention. JCESR is exploring a promising phenomenon that dramatically speeds up ion diffusion: the rotational motion of normally static negative ions (i.e., anions) in the solid-state electrolyte framework that help drive the motion of the  $\text{Li}^+$  positive ions (i.e., cations).

"In fact, it turns out that the anion 'building blocks' that comprise the solid framework are not rigid, but undergo rotational motion," said Nazar. "Our study addresses this principle to show that anion dynamics in the framework of the solid enhance  $\text{Li}^+$  cation transport. The anion dynamics can be 'turned on' even at [room temperature](#) by tuning the framework, and the anion dynamics are strongly coupled to cation diffusion by the paddlewheel effect. This is somewhat akin to the transport of people through a multi-person revolving door."

While new solid electrolytes are still in the developmental stage, the advances are encouraging. A breakthrough would be a game changer and dramatically increase the safety and deployment of Li-ion batteries, according to JCESR Director George Crabtree.

"If you can find a [solid-state electrolyte](#) enabling fast  $\text{Li}^+$  cation motion, it would be a drop-in replacement for liquid organic electrolytes and immediately rid batteries of the thermal runaway reaction, the major cause of fire in today's Li-ion batteries." said Crabtree. "For its safety advantages alone, there would be a huge market for it in cell phones, laptops, video recorders, autos and the electricity grid."

The intellectual enthusiasm for solid-state batteries is shared across JCESR. Other collaborators at University of Michigan and MIT also are exploring solid electrolytes and the paddlewheel effect. Solid-state batteries are one of the most promising and sought-after advances for industry, said Crabtree.

"JCESR wants to understand the atomic and molecular level origins of [battery](#) behavior. With this knowledge, we can build the battery from the bottom up, atom-by-atom and molecule-by-molecule, where every atom and molecule play a prescribed role in producing the targeted battery behavior," Crabtree said. "The paddlewheel effect is an example of that. This paper is at the very frontier of solid [electrolyte](#) behavior, and we want to transfer this knowledge to the commercial sector."

**More information:** Zhizhen Zhang et al, Targeting Superionic Conductivity by Turning on Anion Rotation at Room Temperature in Fast Ion Conductors, *Matter* (2020). [DOI: 10.1016/j.matt.2020.04.027](https://doi.org/10.1016/j.matt.2020.04.027)

Provided by Argonne National Laboratory

Citation: JCESR lays foundation for safer, longer-lasting batteries (2020, June 4) retrieved 11 May 2024 from <https://phys.org/news/2020-06-jcesr-foundation-safer-longer-lasting-batteries.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.