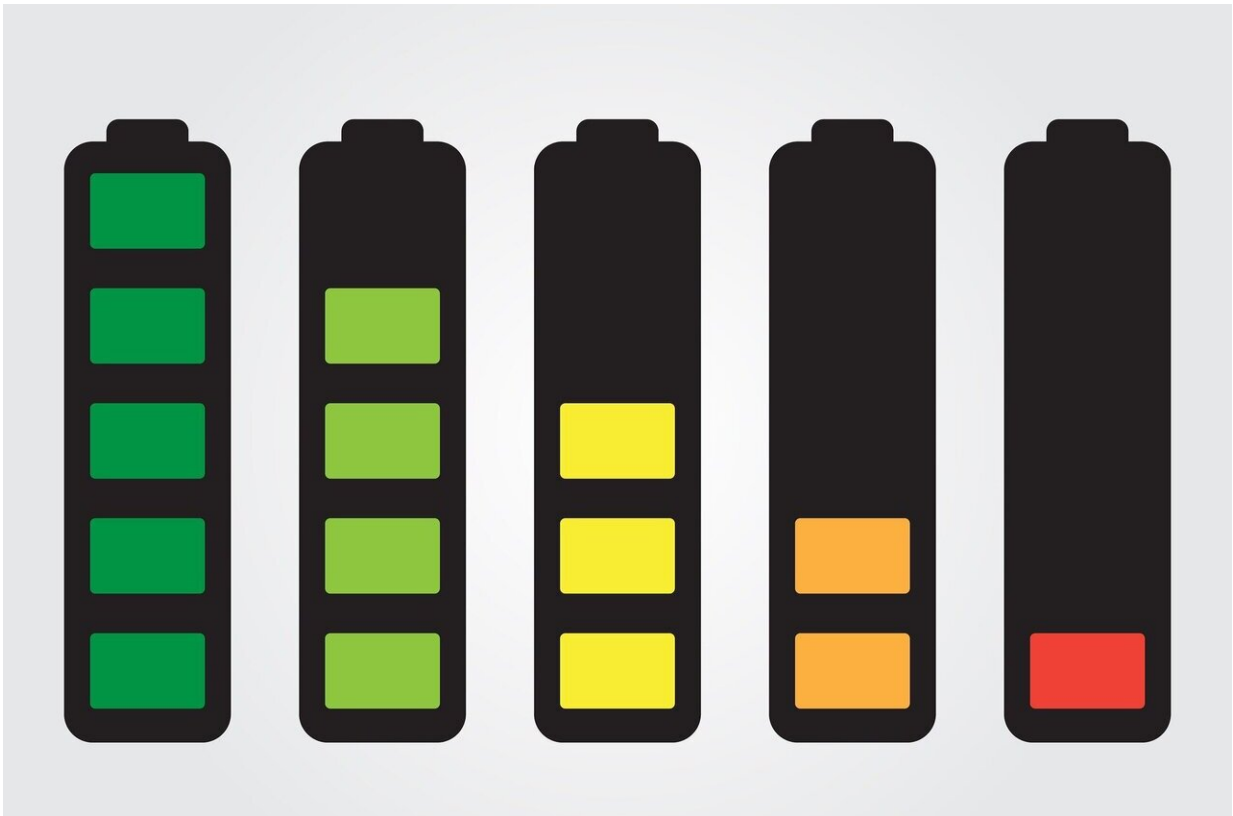


# Engineers evaluate the factors affecting battery performance at low temperatures

May 20 2022

---



Credit: CC0 Public Domain

Energy storage with rechargeable battery technologies powers our digital lifestyles and supports renewable energy integration into the power grid. However, battery function under cold conditions is an ongoing challenge,

motivating researchers to improve low temperature performance of batteries. Aqueous batteries (in a liquid solution) do better than non-aqueous batteries in terms of rate capability (a measure of energy discharged per unit of time) at low temperatures.

New research from engineers at the China University of Hong Kong published April 17 in *Nano Research Energy* proposes optimal design elements of aqueous electrolytes for use in low [temperature](#) aqueous batteries. The research reviews the physicochemical properties of aqueous electrolytes based on several metrics: phase diagrams, ion diffusion rates, and the kinetics of the redox reactions.

The main challenges for low temperature aqueous batteries are that the electrolytes freeze, the ions diffuse slowly, and the redox kinetics (electron transfer processes) are consequently sluggish. These parameters are closely related to the physicochemical properties of the low temperature aqueous electrolytes used in batteries.

To improve battery performance under cold conditions, therefore, requires understanding how the electrolytes respond to cold ( $-50\text{ }^{\circ}\text{C}$  to  $-95\text{ }^{\circ}\text{C}$ ). Study author and associate professor Yi-Chun Lu says that "to obtain [high performance](#) low temperature aqueous batteries (LT-ABs), it is important to investigate the temperature dependent physicochemical properties of aqueous electrolytes to guide the design of low temperature aqueous electrolytes (LT-AEs)."

## Evaluating aqueous electrolytes

The researchers compared various LT-AEs used in [energy storage](#) technologies, including aqueous  $\text{Li}^+/\text{Na}^+/\text{K}^+/\text{H}^+/\text{Zn}^{2+}$ -batteries, supercapacitors, and flow batteries. The study collated information from many other reports regarding the performance of diverse LT-AEs, for example an antifreezing hydrogel [electrolyte](#) for an aqueous  $\text{Zn}/\text{MnO}_2$

battery; and an [ethylene glycol](#) (EG)-H<sub>2</sub>O based hybrid electrolyte for a Zn metal battery.

The study systematically examined equilibrium and non-equilibrium phase diagrams for these reported LT-AEs in order to understand their antifreezing mechanisms. The phase diagrams showed how the electrolyte phase changes across changing temperatures. The study also examined conductivity in LT-AEs with respect to temperature, electrolyte concentrations, and charge carriers.

Study author Lu predicted that "ideal antifreezing aqueous electrolytes should not only exhibit low freezing temperature  $T_m$  but also possess strong supercooling ability," i.e. the liquid electrolyte medium should remain liquid even below freezing temperature, thus enabling ion transport at ultra-low temperature.

The study authors found that, indeed, the LT-AEs that enable batteries to operate at ultralow temperatures mostly demonstrate low freezing points and strong supercooling abilities. Further, Lu proposes that "the strong supercooling ability can be realized by improving the minimum crystallization time  $\tau$  and increasing the ratio value of glass transition temperature and freezing temperature ( $T_g/T_m$ ) of electrolytes."

The charge conductivity of the reported LT-AEs for use in batteries could be improved by lowering the amount of energy required for ion transfer to occur, adjusting the concentration of electrolytes, and choosing certain charge carriers that promote fast redox reaction rates. Lu says that "lowering the diffusion activation energy, optimizing electrolyte concentration, choosing [charge carriers](#) with low hydrated radius, and designing concerted diffusion mechanism[s] would be effective strategies to improve the ionic conductivity of LT-AEs."

In the future, the authors hope to further study the physicochemical

properties of electrolytes that contribute to improved aqueous battery performance at [low temperatures](#). "We would like to develop high performance low temperature aqueous batteries (LT-ABs) by designing aqueous electrolytes possessing low freezing temperature, strong supercooling ability, high ionic conductivity, and fast interfacial redox kinetic," says Lu.

**More information:** Yi-Chun Lu et al, Design strategies for low temperature aqueous electrolytes, *Nano Research Energy* (2022). [DOI: 10.26599/NRE.2022.9120003](#)

Provided by Tsinghua University Press

Citation: Engineers evaluate the factors affecting battery performance at low temperatures (2022, May 20) retrieved 3 May 2024 from <https://phys.org/news/2022-05-factors-affecting-battery-temperatures.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.