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New solid electrolyte promises cheaper, better all-solid-state lithium batteries

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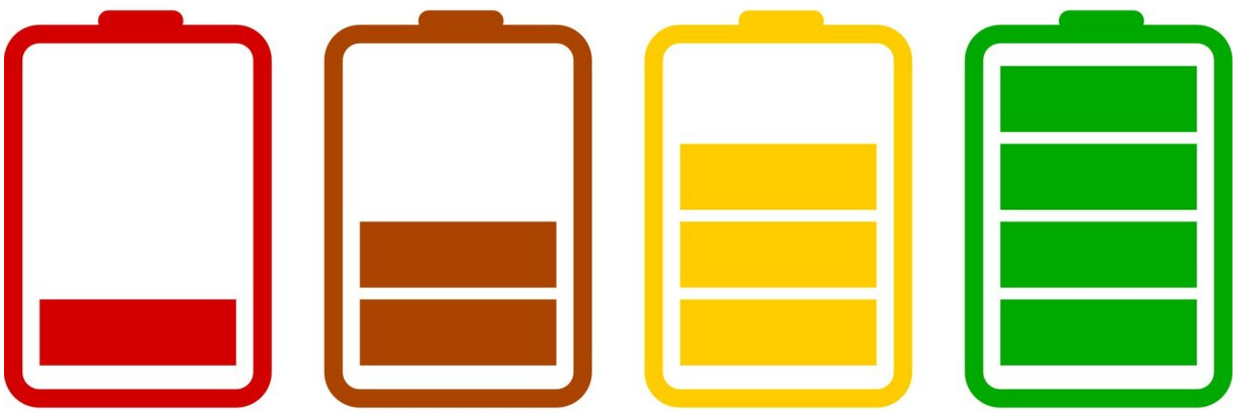

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Researchers from the University of Science and Technology of China (USTC) of the Chinese Academy of Sciences (CAS) have designed a novel material to make all-solid-state lithium (Li) batteries less costly but more effective, according to an article published in the journal *Nature Communications*on July 20.

Solid electrolytes are important to realizing safe, energy-dense all-solid-state Li batteries. Among different types of solid electrolytes, the chloride solid electrolytes were recently found to exhibit the desirable characteristics of both sulfide and oxide systems, including high ionic conductivity, deformability and oxidative stability. The rare combination of these advantages has rapidly attracted wide interest. Nevertheless, two issues are making the mass production of these attractive solid electrolytes extremely challenging: the expensive raw materials, and the low humidity tolerance.

The team designed and synthesized the material, Li_2ZrCl_6 (LZC). With all the advantages of chloride solid electrolytes well preserved, it simultaneously exhibits low materials cost and excellent humidity tolerance.

The raw material cost of LZC at 50 μm thickness is only $1.38/m^2, which is much lower than that of even the cheapest chloride system in the literature ($23.05/m^2), and way below the $10/m^2 threshold for ensuring the cost competitiveness of all-solid-state batteries. Furthermore, LZC is stable in an atmosphere with 5% relative humidity, so the strict requirements for atmosphere during synthesis and storage, like those for sulfide solid electrolytes, are no longer needed.

More importantly, the above advantages in mass production "have been achieved without sacrificing any of the attractive characteristics of chloride solid electrolytes," according to Prof. MA.

LZC still possesses high ionic conductivity (0.81 mS cm^{-1}), outstanding deformability, and remarkable compatibility with 4V-class cathodes. A cell with a $LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$ cathode and a LZC solid electrolyte delivered a stable specific capacity of about 150 mAh g^{-1} after 200 cycles at 200 mA g^{-1} without considerable fade, which rivals even the best among similar all-solid-state cells.

"All-solid-state Li batteries play an important role in achieving the goal of 'peak carbon dioxide emissions' and 'carbon neutrality'," Prof. MA said. "The achievement of both cost-effectiveness and high performance of Li_2ZrCl_6 removes a major obstacle to the commercialization of such batteries."

As for future research, the team will try other 4+ cations, denoted as M, to synthesize Li_2MCl_6 solid electrolytes, and strive to make both better and more affordable all-solid-state batteries.

More information: Kai Wang et al, A cost-effective and humidity-tolerant chloride solid electrolyte for lithium batteries, *Nature Communications* (2021). DOI: 10.1038/s41467-021-24697-2

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