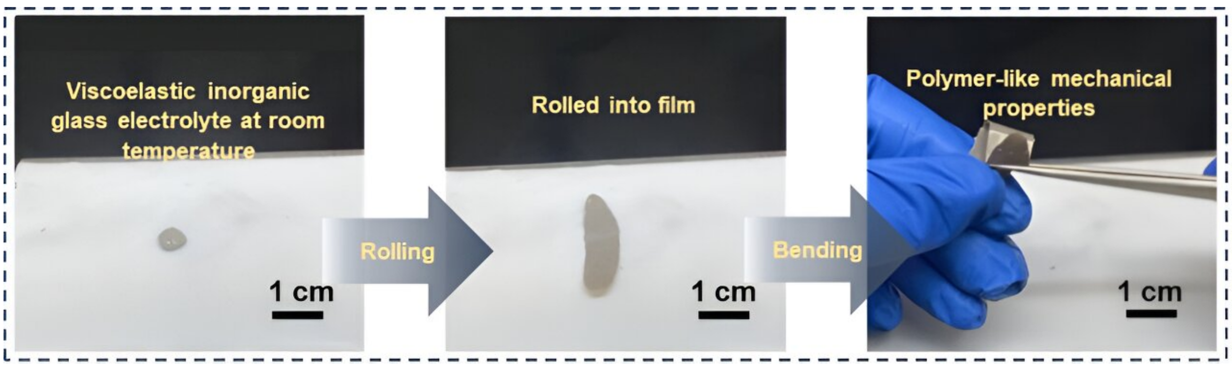
Promising electrolytes for solid-state batteries based on viscoelastic inorganic glass

November 2 2023, by Ingrid Fadelli



The viscoelastic inorganic glass (VIGLAS) electrolyte is hand-rolled to a thin film with high deformability at room temperature. Credit: Dai et al

Recent advancements in the development of hybrid and electric vehicles have increased the need for highly performing battery technologies. Research teams worldwide have thus been working on a wide range of alternative battery solutions, while also trying to identify new promising electrolytes for these batteries.

Batteries containing solid electrodes and a solid electrolyte, known as solid-state batteries, could be a viable alternative energy storage solution for electric vehicles. However, the traditional inorganic ceramic electrolytes and organic polymer electrolytes often suffer from either poor flexibility or mechanical properties, which adversely impacts the batteries' performance.

Researchers at the Chinese Academy of Sciences recently discovered new electrolytes for solid-state batteries based on a class of viscoelastic inorganic glass (VIGLAS). Their paper, published in *Nature Energy*, shows that these electrolytes possess characteristics of both inorganic and organic electrolytes and could significantly improve the stability of all-solid-state battery cells.

"We initially wanted to find an inorganic solid electrolyte with a low melting point to simplify the assembly process of the solid-state battery in a slightly elevated temperature environment, which is similar to liquid Na-ion batteries," Yong Sheng Hu, one of the researchers who carried out the study, told Tech Xplore.

"Based on the previous research on molten salt battery using $LiAlCl_4$/$NaAlCl_4$ electrolyte (which has the lowest melting point in molten salts), we tried find some methods to partially substitute of Cl atoms to improve the ionic conductivity in the solid state. Finally, we found that by introducing O atoms to vitrify it, the ionic conductivity at room temperature could be improved by three orders of magnitude, and unexpectedly found that it has viscoelasticity similar to that of organic polymers."

The key objective of the recent work by Hu and his colleagues was to unveil new promising and scalable electrolytes for solid-state batteries. Firstly, the researchers synthesized their VIGLAS-based solid electrolytes, which are based on the material $MAlCl_{4-2x}O_x$ (MACO, M=Li, Na, 0.5

"VIGLAS materials possess high ionic conductivity (~1 mS cm^{-1} at 30°C) for both Li^+ and Na^+, superior chemo-mechanical compatibility with 4.3 V cathodes, as well as the ability to enable pressure-less Li- and

Na-based solid-state batteries (

The class of inorganic glass identified by this team of researchers has a unique combination of inorganic-like properties, including high ionic conductivity, strong oxidative resistance, and polymer-like flexible feature that enable compatibility with widely used cathodes. In initial tests, electrolytes based on this glass achieved highly promising results, infiltrating electrode materials as well as liquid electrolytes.

Notably, the team's electrolytes could also be easy to scale up and could be fabricated using existing fabrication processes. As they are based on deformable materials, they could be produced on a large-scale through simple rolling processes.

"We demonstrate there is no obvious boundary between organic polymer electrolytes and inorganic electrolytes," Hu added. "The inorganic electrolytes can also have the polymer-like mechanical properties, which enables the pressure-less Li- and Na- based solid-state cells. In our next studies, we plan to explore some other similar VIGLAS electrolytes with Li/Na-metal anode stability."

More information: Tao Dai et al, Inorganic glass electrolytes with polymer-like viscoelasticity, *Nature Energy* (2023). DOI: 10.1038/s41560-023-01356-y