

# Printable Electrolytes: A New Route Toward All-Solid-State Batteries

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The forthcoming smart energy era, which will involve the widespread use of flexible/wearable electronic devices, the Internet-of-Things (IoTs), electric vehicles (EVs) and grid-scale energy storage systems (ESSs), has spurred the relentless pursuit of high-energy/safe rechargeable power sources. In particular, recent fire/explosion accidents of lithium-ion batteries (LIBs) have inspired us to devote greater attention to safety failures. Bipolar all-solid-state LIBs have garnered considerable attention as a promising approach to simultaneously addressing the aforementioned safety concerns as well as challenges associated with the limited energy density of current LIBs. A key component enabling the bipolar batteries is solid-state electrolytes. To prevent flow of ions between the adjacent cells inside the bipolar batteries, nonfluidic solid-state electrolytes are essentially required. To date, (sulfide or oxide-based) inorganic solid electrolytes have been extensively investigated as attractive candidates. However, their stringent problems, including poor ionic conduction, high grain boundary resistance, mechanical brittleness, chemical/electrochemical instability, complicated material synthesis and high-pressure/high-temperature sintering-based cell fabrication processes, still remain formidable obstacles to practical application.

Here, we present a new class of printable electrolytes as an unprecedented material strategy to address the longstanding issues of conventional inorganic electrolyte-based bipolar LIBs. The printable electrolytes are rationally designed to act as a self-standing, ion-conductive separator membrane and also as an electrolyte in the printable electrodes, after ultraviolet (UV) curing-induced solidification. Elaborate combination of the printable electrolytes and high-fidelity printing techniques allows facile fabrication of bi-polar all-solid-state LIBs. The new bipolar LIBs are easily fabricated through solvent-drying-free, UV-curing-assisted multistage printing. Note that this multistage printing process does not require high-pressure/high-temperature sintering processes commonly adopted for inorganic-electrolyte-based all-solid-state LIBs. Rheology tuning of the electrode and electrolyte pastes, in combination with the multistage printing, enables the monolithic integration of (in-series/in-plane) bipolar-stacked cells with reliable/sustainable electrochemical performance onto complex-shaped objects. The printed bipolar LIBs show exceptional performance in mechanical flexibility, form factors and abuse tolerance (nonflammability) that far exceed those achievable with conventional inorganic-electrolyte-based cell technologies. We believe that the printable electrolytes described herein hold great promise as an effective and scalable platform technology to move bipolar all-solid-state batteries one step closer to commercialization.

## References

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