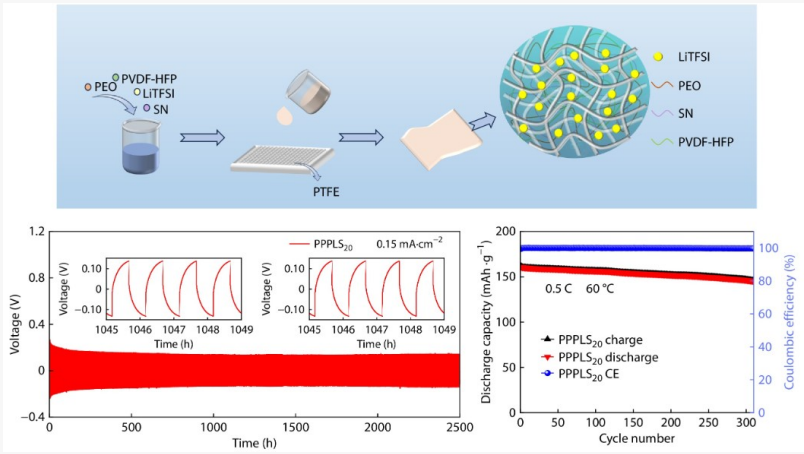
Solid, tough, and fast: a composite electrolyte that helps tame lithium dendrites

GA, UNITED STATES, March 19, 2026 /EINPresswire.com/ -- Solid-state lithium metal batteries could deliver higher energy density and improved safety, but polymer electrolytes often force a trade-off: materials that conduct ions well can be too soft to block lithium dendrites, while tough polymers tend to conduct poorly. A new composite solid polymer electrolyte addresses both problems by integrating a porous fibrous scaffold with a plastic-crystal additive to enhance ion transport while maintaining mechanical resilience. The optimized electrolyte forms a continuous, well-infiltrated structure that supports stable lithium plating/stripping for thousands of hours and enables long-life cycling in full cells. The results suggest a scalable design pathway for safer, longer-lasting lithium metal batteries.



PTFE-Scaffolded Composite Polymer Electrolyte Enables Long-Life Lithium-Metal Cycling.

Liquid electrolytes enable fast ion transport but can raise safety concerns, and lithium metal anodes—despite their high capacity—can grow dendrites that trigger short circuits and rapid failure. Solid polymer electrolytes are attractive because they are processable and potentially compatible with lithium metal, yet many polymer systems (especially PEO-based) become highly crystalline at room temperature, restricting Li mobility. Adding plasticizers can improve conductivity, but excessive softening may weaken mechanical protection and destabilize interfaces. Meanwhile, strengthening the polymer often worsens ionic transport, leaving researchers stuck between conductivity and robustness. Based on these challenges, deeper research is needed to develop solid polymer electrolytes that simultaneously deliver high ionic conductivity and high mechanical strength.

Researchers at Zhejiang Sci-Tech University report a fiber-reinforced composite solid polymer electrolyte designed to overcome the long-standing “conductivity–strength” dilemma in polymer-based solid-state batteries. In a study published (DOI: 10.1007/s10118-025-3515-3) online on January 19, 2026 in the Chinese Journal of Polymer Science, the team shows that combining a

porous PTFE fibrous membrane (as a reinforcing framework) with the plastic-crystal additive succinonitrile yields an electrolyte that is both mechanically robust and electrochemically effective for lithium metal battery operation.

The team's concept borrows from structural engineering: a lightweight porous framework provides mechanical reinforcement, while the polymer phase supplies ion transport. They infiltrated a PEO/PVDF-HFP/LiTFSI matrix containing succinonitrile into a porous PTFE fibrous membrane via solution casting, aiming for uniform filling and intimate interfacial contact. Microscopy suggests the PTFE scaffold helps "hold" the electrolyte in a continuous network, while the succinonitrile component improves wetting and reduces PEO crystallinity—two factors expected to open faster Li□ pathways.

Material optimization mattered. At an optimized 20 wt% succinonitrile, the electrolyte achieved an ionic conductivity of 7.6×10□⁴ S·cm□¹ at 60 °C while retaining strong mechanical performance, reaching 3.31 MPa tensile strength with 352% elongation—a combination intended to resist dendrite penetration without sacrificing flexibility. Electrochemically, the composite sustained lithium symmetric-cell cycling for about 2,500 hours at 0.15 mA·cm□², indicating stable interfacial behavior during repeated plating/stripping. In Li//LiFePO□ full cells, the electrolyte delivered durable cycling with 91.6% capacity retention after 300 cycles at 0.5C and coulombic efficiency consistently above 99.9%, supporting the claim that the composite design improves both stability and longevity.

According to the authors, the performance comes from a deliberate "division of labor" inside the composite. The PTFE fibrous membrane acts as a thermally stable, mechanically strong backbone that helps maintain structural integrity under cycling stress. Succinonitrile suppresses polymer crystallinity and promotes faster Li□ transport, while PVDF-HFP improves salt dissolution and contributes to electrochemical stability. Together, these components create a reinforced yet conductive electrolyte architecture that can be fabricated by straightforward casting and still deliver long-duration symmetric-cell stability and reliable full-cell cycling.

For solid-state lithium metal batteries to become practical, electrolytes must be manufacturable at scale, mechanically resilient, and consistently conductive—especially under conditions where dendrites are likely. This work points to a pragmatic materials strategy: instead of chasing a single "perfect" polymer, build composites in which a porous fiber scaffold provides structural protection and a carefully tuned additive accelerates ion transport. The demonstrated thousands-hour lithium cycling stability and strong capacity retention in LiFePO□ full cells suggest potential for safer, longer-lived energy storage. If the approach translates to broader cathode chemistries and lower-temperature operation, it could help move polymer-based solid-state batteries closer to real-world deployment.

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Lucy Wang
BioDesign Research
email us here