

Polysiloxane-Based Single-Ion Conducting Polymer Electrolyte for Na-Metal Batteries

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Sodium-metal batteries (SMBs) are regarded as promising next-generation energy storage systems, but continue to face critical challenges such as an unstable solid electrolyte interphase and dendritic sodium metal growth. These issues primarily arise from the intrinsic reactivity of sodium towards classic liquid electrolytes. To address these challenges, the development of advanced electrolyte systems is crucial.

Herein, we present a novel polysiloxane-based single-ion conductor (NaPSiO). Blending NaPSiO with poly (vinylidene fluoride-co-hexafluoropropylene) and incorporating small organic carbonate molecules with a high dielectric constant, supporting the charge transport, yields self-standing polymer membranes with a high ionic conductivity of, e.g., 0.35 mS cm⁻¹ at 40 °C and a wide electrochemical stability window beyond 4.4 V. Remarkably, symmetric Na||Na cells employing this electrolyte demonstrate stable cycling for over 2,000 h, which is attributed to its single-ion conducting behavior and the formation of a robust interphase on the sodium surface. Moreover, Na|NaPSiO|Na||Na₃V₂(PO₄)₃ full-cells exhibit exceptional long-term cycling stability with 96% capacity retention after 1,000 cycles – even in large-format cells and with commercially relevant cathode active material mass loadings of up to 20 mg cm⁻².