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1D nanoporous membrane boosts the ionic conductivity of electrolytes

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Solid-state batteries have attracted significant interest as promising candidates for high energy density and safe battery technology. However, they commonly experience low ionic conductivity at ambient temperature, which limits their power density. This study addresses this issue by developing a porous separator with one-dimensional (1D) nanometric channels that confine non-flammable ionic liquid-based electrolytes (ILLi). We achieve 1D macroscopic ionic transport by confining the electrolytes within Vertically Aligned Carbon NanoTubes (VA-CNT) composite membranes. Employing quasi-elastic neutron scattering techniques, we conduct a multiscale analysis of the diffusive motion of both bulk and confined electrolytes. By extracting diffusion coefficients spanning from the molecular to macroscopic scale, we gain insights into the transport properties of IL-Li. Our results show that nanometric confinement allows to lower the operational temperature of these electrolytes by up to 20 K compared to the non-confined electrolytes. At ambient temperature, we show a tenfold increase in conductivity under 1D CNT confinement. Molecular Dynamics simulations shed light on the underlying physics, showing a unique intermolecular organization of the IL-Li under confinement. Specifically, the molecules form a core–shell structure, resulting in the creation of quasi-1D transport channels. This study presents promising avenues for exploring the use of 1D materials in energy storage applications.

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