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Title: Solid State Electrolyte Membrane Facilitated by a Self-Healing Polymer

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An optimal method of processing a solid-state battery would encompass a cheap, scalable process, one that doesn't impede the conduction capabilities, and the materials used should be mechanically pliant to suppress cracking. In this work, we report a new method of developing a solid electrolyte-in-polymer matrix (SEPM) to form our electrolyte layer. This method takes advantage of the fact that the solid electrolyte pellet is about 15% porous in the green body state. By filling empty voids with an organic polymer, we can create a cross-linked polymer matrix *in situ* to provide mechanical robustness while preserving lithium ion transport pathways in between solid electrolyte particles. Using a newly derived malleable thermoset polymer paired with a Li_2S-P_2S_5 inorganic electrolyte, we produce a stand-alone membrane of 64 μm in thickness, high inorganic material loading (80%), and near theoretical density. The membrane performs on par with traditionally prepared solid-state batteries yet has increased the gravimetric and volumetric cell energy densities by an order of magnitude. The processing of our SEPM is completely dry representing not only a new method of processing for batteries, but a technique to form other composites such as high mass-loading mixed matrix membranes.