Ion conducting polymers that emulate LiPON. Towards all solid-state batteries (ASBs)

Eleni Temeche, Xinyu Zhang, Richard M. Laine*
Dept. of Materials Science and Engineering, University of Michigan, Ann Arbor, MI 48109-2136.
talsdad@umich.edu

Cycling lithium and sodium batteries containing liquid electrolytes often leads to uneven plating of metal on charging that generates dendrites that penetrate the polymer membranes used to separate anodes from cathodes that are coincidentally permeable to dissolved electrolytes. The resulting short circuiting leads to cell failure prompting investigation of ceramic electrolytes thought to mechanically block dendrites from bridging. The search for ceramic electrolytes that offer Li^+ conductivities of 0.1-1 mS/cm has focused on LATP and c-LLZO. Unfortunately, LATP undergoes irreversible reduction of Ti^{4+} during cycling and c-LLZO is susceptible to Li dendrite penetration along grain boundaries. One solution has been to use very thin films (5-200 nm) of gas phase deposited, amorphous LiPON to block this behavior. Unfortunately LiPON thin films offer Li^+ conductivities of 10^{-3} to 10^{-5} mS/cm that mandate the use of thin films.

We have successfully synthesized LiPON-like polymers in an effort to explore their utility in the assembly of ASBs. We report here that these polymers show ambient conductivities of up to 1 mS/cm and can be used to assembly ASBs with lithium sulfur cathodes and Li anodes that offer cyclability with energy densities of $\geq$ 750 mAh/g_{sulfur} over 200 h and 100 cycles at 0.5C with > 90 % efficiency.