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Block-Copolymer Lithium Battery Electrolytes

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With high energy density at low cost, Li ion has become the most prevalent portable rechargeable battery chemistry in the world. As demand for smaller and lighter batteries grows, the energy density limitation of Li ion batteries presents a significant hurdle. Pushing the existing Li ion platform to higher energy densities compromises lifetime and safety, and these have emerged as the most pressing challenges in today's industry. The weakest link in terms of safety and stability of Li ion batteries is the organic liquid electrolyte that facilitates ionic transport between the electrodes. The continuous electrochemical degradation of the electrolyte at the electrodes causes poor cycle life of the batteries, and in some cases, runaway reactions that lead to explosions. Dry polymer electrolytes coupled to Li metal anodes had been considered a high energy alternative to liquid-based systems, as the solid-solid interface promised to alleviate the stability problems of the liquid electrolyte. However, repeated cycling of Li metal anodes leads to dendrite formation, reducing battery life and compromising safety. Recent theoretical work indicates that dendrite growth can be stopped if the shear modulus of current polymer electrolytes can be increased by three orders of magnitude without a significant decrease in ionic conductivity. Thus, the mechanical properties of polymer electrolytes are particularly important in rechargeable solid-state lithium batteries. Because ion transport in polymers is coupled to the motion of the molecules that are solvating the ions, the presence of mobile molecules is essential to allow for a conductive medium. However, the same mobility of molecules is detrimental to the polymer's structural integrity. There is, thus, a clear need to develop methodologies for decoupling the conductive and mechanical properties of polymer electrolytes. Electrolytes comprised of self-assembled block-copolymer nanostructures overcome this principal constraint.