Lithium metal batteries based on new single-ion BAB triblock copolymers as solid electrolytes

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Today the environment is a major society concern and the polluting fossil energy consumption, more and more expensive, is a drag on our economy, thereby the development of alternative transportation such as electric or hybrid vehicles, has become a key need for a sustainable long term development[1]. The increase of energy density necessary to promote this future revolution imposes to develop "new" chemistries for both the active electrode materials and electrolyte[2,3]. The lithium metal as anode becomes the latest flavour for tomorrows' battery based notably on Li-S and Li-air systems[4]. However, the use of lithium metal in batteries based on liquid electrolyte led unfortunately to safety problems associated to the formation of irregular metallic lithium electrodeposits during the recharge, which results in dendrite formation responsible for explosion hazards. The use of a solid polymer electrolyte (SPE) could solve most of the safety issues encounter with liquid electrolyte. However, the development of SPE has been hampered by two hurdles i/ the inability to design a SPE that has both a high ionic conductivity and good mechanical properties[3] and ii/ the motions of lithium ions carry only a small fraction of the overall ionic current which leads during battery operation to the formation of strong concentration gradient with highly noxious effects like favored dendritic growth[5] and limited energy density especially when power increases.

Here we describe the physico-chemical and electrochemical properties of a new single-ion polymer electrolyte based on self-assembled polyanionic triblock copolymers BAB in order to finely tune the mechanical properties as well as the ionic conductivity and lithium transport number. The B block is a polyanionic polymer based on Poly(styrene trifluoromethanesulfonylimide of lithium) P(STFSILi) associated with a central A block based on a linear Poly(ethylene oxide) PEO. The single-ion conductivity is almost one order of magnitude higher than that of the state of the art for such materials (1.310^{-5} Scm^{-1} at 60°C) combined with a mechanical strength drastically improved. The electrochemical window stability is extended to more than 5 V. Battery prototypes have been assembled using a cathode formulated with $LiFePO_4$ as active material. The battery tests show that the power performances and cycling are outstanding particularly at 60°C which makes these materials highly attractive for next battery generation[6].

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