

## **Optimization of block copolymers as electrolytes for Lithium metal batteries.**

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Lithium-ion batteries are the most used energy storage devices for portable applications. Beside energy density limitation and high cost for high scale applications a safety issue comes from the liquid electrolytes as they embedded inorganic solvents that can likely leak or generate flammable reactions. One solution is to use a solid polymer electrolyte (SPE) with a lithium metal anode [1] to increase both safety and energy density.

The fundamental SPE is poly(ethylene oxide), PEO, as it contains coordination sites allowing lithium salt dissociation and its flexible structure enables the ionic transport. Such batteries operate at temperature where PEO is in a melted state to ensure sufficient ionic transport but is mechanically too weak to avoid dendritic growth [2] due to the non uniform lithium electrodeposition at the anode during recharge.

This key limiting factor can be overcome by using block copolymers [3-5] as electrolyte. A block copolymer is composed of conductive A blocks doped with a lithium salt based on PEO either linear or branched on a synthetic backbone such as poly(methacrylate of ethylene oxide), P(MAPEG); and reinforced B blocks with a high glass transition temperature like polystyrene, PS. These

materials can self-organize in nanometric domains. The interfaces between the domains generate sufficient mechanical properties at the macroscopic level whilst, locally, the PEO chain dynamics remain high, ensuring ionic conduction.

The objective of the study is first to compare the thermodynamical, mechanical and electrical properties of these electrolytes depending on their architectures, triblock (B-A-B, A-B-A) or diblock (B-A). The impact of the chain length and weight proportion of PEO are studied on PS-POE-PS. The architecture influence, diblock vs. triblock and linear PEO vs. branched PEO is evaluated thanks to electrolytes composed of PS and P(MAPEG) as B and A block, respectively.

At last, we use these electrolytes in Lithium metal battery to compare their performances. After the formulation of cathodes using LiFePO<sub>4</sub> as active material, plastic batteries were assembled and successfully tested by galvanostatic cycling under temperature [40°C-100°C] and high regime. Finally, a 6 mAh prototype realized more than 500 cycles under the regime C/4 and D/2 at 100°C.

### References:

- [1] J-M. Tarascon, M. Armand, *Nature* 414 (2001) 359.
- [2] M. Dollé et al., *E.S.L.* 5 (2002) A286.
- [3] A. Panday et al., *Macromolecules* 42 (2009) 4632.
- [4] D.R. Sadoway, *J. Power Sources* 129 (2004) 1.
- [5] T. Niitani et al., *J. Power Sources* 146 (2005) 386.