Materials and processing methods for stable lithium-metal batteries

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Solid-state Lithium-Metal (Li°) Batteries (LMBs) are foreseen as enablers for *safer-by-design* and higher energy density post-Lithium-ion electrochemical energy storage 2.0 solutions. They are considered as part of the solutions to address the United Nation Sustainable Development Goal N°7 and to reach a carbon neutral European continent by 2050. As LMB-based materials are (at least in part) different from the ones currently used in *state-of-the art* Li-ion Batteries (LiBs), this is creating a technology push to adjust processing methods for manufacturing Generation 4b batteries. Shifting paradigm from LiBs to LMBs is also calling for major improvements of their lifetime as their interfaces are (i) prone to degradation or (ii) can suffer from dendrite growth or contact loss.

Soft-matter-based organic electrolytes offer here an innovative and scalable materials platform to manufacture LMBs and ways to improve their lifetimes through varying their chemical structures and processing. We will present results implementing this strategy from the ongoing Battery 2030$^+$ HIDDEN project [1], where Thermotropic Ionic Liquid Crystals (TILCs), the 'materials marriage' of Thermotropic Liquid Crystals (TLCs) with ionically conducting materials, have been developed as a new generation of self-healing electrolytes (see **Figure 1**) aiming specifically at (i) mitigating Li° dendrite growth and (ii) increasing the lifetime of LMBs.

TLCs are fluid-like but dynamically ordered self-assemblies under a certain temperature range. If used as electrolytes, TLCs need to be engineered to encode ionic transport features for generating TILCs specifically designed to assist controlled Li^+ transport and to ensure smooth Li deposition onto a Li° electrode, preventing dendrite formation. We will discuss how HIDDEN has leveraged this concept through a series of TILCs enabling a scalable process to coat the electrolytes onto/within the electrodes and to generate data for modelling, thereby implementing the MAP and BIG-MAP concepts at the heart of the Battery 2030$^+$ initiative. In closing, we will also disclose a few highlights from two other projects where we are developing materials and processing methods with polymeric electrolytes for LMBs: A national Finnish project NextGenBat [2] and the just-started Horizon Europe project SOLiD.

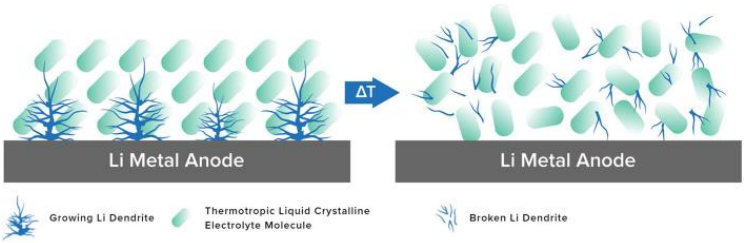

Figure 1. *Schematic of the self-healing method based on a liquid crystalline electrolyte.*

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References:

[1] https://battery2030.eu/battery2030/projects/hidden and https://hidden-project.eu/
[2] https://www.aalto.fi/en/department-of-chemistry-and-materials-science/nextgenbat