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### ► **To cite this version:**

Manuel Maréchal, Hélène Pung, Celso Yassuo Imp Okada-Junior, Mirella Simoes Santos, Sébastien Livi, et al.. Thermotropic Ionic Liquid Crystals: Structure/ion transport correlation within stimuli-responsive electrolytes for energy. International Society of Electrochemistry, International Society of Electrochemistry, Sep 2023, Lyon, France. ⟨hal-04442311⟩

**HAL Id: hal-04442311**

**<https://hal.science/hal-04442311v1>**

Submitted on 6 Feb 2024

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# Thermotropic Ionic Liquid Crystals: Structure/ion transport correlation within stimuli-responsive electrolytes for energy

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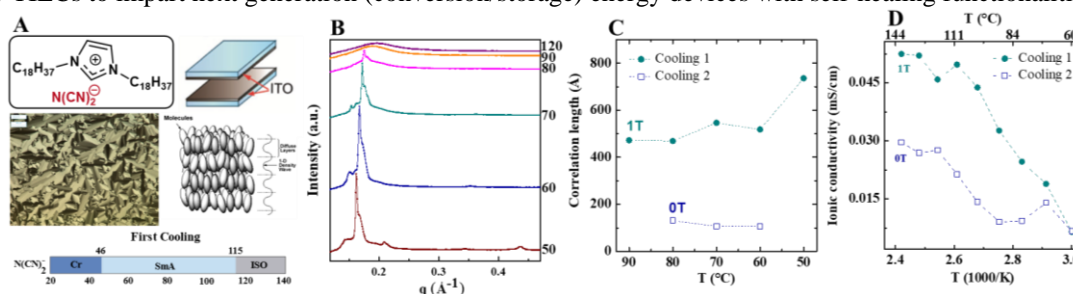
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Thermotropic Ionic Liquid Crystals (TILCs)<sup>1</sup> have recently emerged as a smart class of organic electrolytes encoding the unique hierarchical self-assembling properties and stimuli-responsive mosaicity of mesophases featured by thermotropic liquid crystals<sup>2</sup> with the efficient ion transport of ionic liquids. As a result, TILCs stand out as a promising electrolytic platform for energy storage (batteries<sup>3</sup>/supercapacitors) and conversion (fuel cells/DSSCs) as they use industry-compatible and simple-to-implement manufacturing processes. The multi-scale correlation relating their structures and (an/cat)ionic transport properties is crucial to pave understanding of their ionic transport. A fundamental question of interest is here the influence of the dynamical mosaicity related to the average size of their self-assembled domains, with or without (w vs. w/o) dynamic grain boundaries. Remarkably, stimuli such as electric<sup>4</sup> or magnetic field can be leveraged to sample (dis)order till ultimately reaching monodomains (eradication of mosaicity) to reveal inherent (*i.e.* defect-free) features of their ionic transport.

Exploring this research endeavour, in this communication, the case study of an anionic conductive TILC (A-TILC) composed of an imidazolium-based cation with symmetrical *n*-alkyl chains (C<sub>18</sub>C<sub>18</sub>Im<sup>+</sup>) and a N(CN)<sub>2</sub><sup>-</sup> anion featuring a Smectic A (SmA<sup>5</sup>) mesophase (lamellar organization) will be deciphered by combining *state-of-the-art* (SoA) theoretical and experimental approaches. First, coarse-grained simulations derived from Martinelli<sup>6</sup> will be presented to unravel its set of structural and dynamic descriptive parameters. Second, an unique *operando* experiment combining (synchrotron-based) SoA structural studies (SAXS+WAXS) with ionic transport measurements (probed by EIS) w vs. w/o a tuneable (0 up to 1T) magnetic field (**Fig. 1**) will be introduced, allowing in-depth study of the interplay linking its structure with its ion transport properties. In closing and beyond the case study of an A-TILC encoding a nanoconfined 2D transport within a SmA mesophase, we will illustrate the potential offered by TILCs to impart next generation (conversion/storage) energy devices with self-healing functionalities.



**Fig.1.** A. Chemical structure of the C<sub>18</sub>C<sub>18</sub>Im<sup>+</sup>/N(CN)<sub>2</sub><sup>-</sup> TILC, LC cell (through-plane configuration) and mesomorphic behaviours (phase transition and texture) of its SmA mesophase. B. 1D SAXS/WAXS scattering profiles (first heating) as a function of temperature. C. vs. D. Temperature dependent evolution of the correlation length (average domain size) and ionic conductivity w vs. w/o 1T magnetic field.

**Acknowledgments:** We are indebted to the French National Agency of Research (ANR) for the funding of the collaborative research project CITADEL under the grant ID # [ANR-19-CE05-0028](#). The coauthors acknowledge [ESRF-EBS](#) for beamtime allocation at [ID31](#) under the SC-5292 proposal (DOI: 10.15151/ESRF-ES-894751246).

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