

Ionic Liquids: bulk vs 1D CNT confinement. Towards better batteries?

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composite polymer membranes made out of vertically aligned carbon nanotube (CNT) forests. As this system shows no tortuosity and no friction at the electrolyte / CNT interface, the transport properties within the pore system (the interior of the CNTs) are expected to be tremendously enhanced. We actually have recently shown¹ that, compared to the bulk situation, such 1D CNT nanometric confinement induces a conductivity gain of the electrolyte as high as 50. We interpret this result as a possible revelation of a superlubricity phenomenon under confinement². Such 1D CNT membrane making possible an ultra-fast travel of the ions in between the electrodes of a battery separator is an appealing route to boost the power density of batteries (Fig. 1). A patent has been filed³.

In this framework, a thorough multiscale characterization of the confined electrolyte is essential. The competition between electrostatic and van der Waals interactions leads to a property original for pure ILs: they self-organize in fluctuating nanometric aggregates. So far, this transient structuration has escaped direct clear-cut experimental assessment. In bulk, we have taken advantage of the alliance of QENS (Tof and NSE), PFG-NMR and particle-probe rheology to i) catch this phenomenon and ii) highlight an unexpected consequence: a one order of magnitude difference of the transport quantities, depending whether they are inferred at the molecular or at the micrometric scale⁴. Along with electrochemical impedance spectroscopy data, we will also show Tof and PFG-NMR measurements of the same IL confined in the CNT membranes.

1. Berrod, Q. et al. Ionic liquids confined in 1D CNT membranes:gigantic ionic conductivity. ArXiv171006020 Cond-Mat (2017).
2. Heiranian, M. & Aluru, N. R. Nanofluidic Transport Theory with Enhancement Factors Approaching One. *ACS Nano* 14, 272–281 (2020).
3. Berrod, Q., Ferdeghini, F., Judeinstein, P. & Zanotti, J.-M. Nanocomposite membranes for electrochemical devices. Patent WO 2016151142 A1. (2016).
4. Berrod, Q. et al. Ionic Liquids: evidence of the viscosity scale-dependence. *Sci. Rep.* 7, (2017).

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