Electronic Supplementary Material (ESI) for Energy & Environmental Science.

Exceptional long-life Performance of lithium-ion batteries using ionic liquid-based electrolytes

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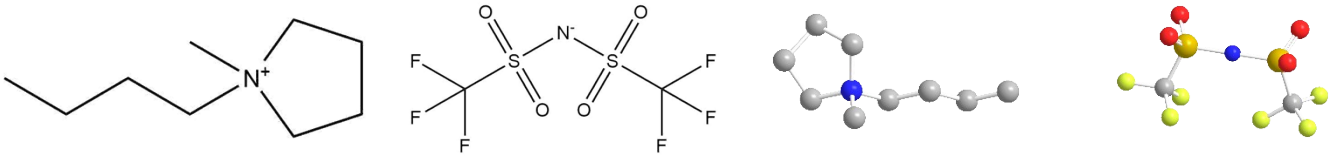
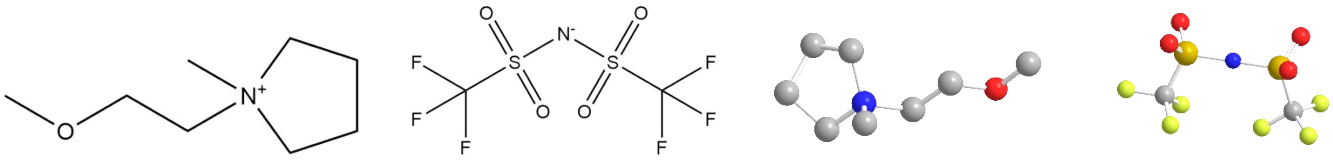
Supplementary Information



(a)



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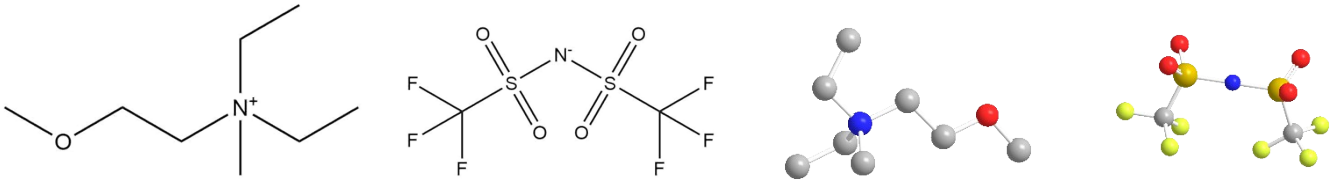

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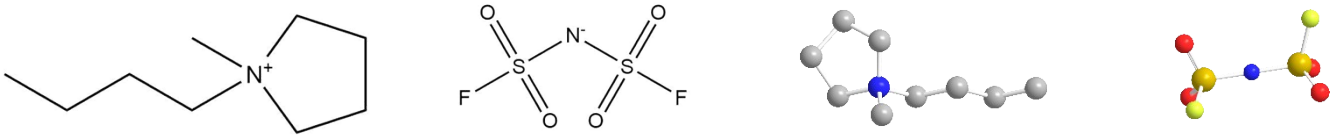


(d)

Figure S1 Structural details of the studied ionic liquids. a) N-butyl-N-methylpyrrolidinium bis(trifluoromethanesulfonyl)imide ($Pyr_{14}TFSI$), b) N-methoxy-ethyl-N-methylpyrrolidinium bis(trifluoromethanesulfonyl)imide ($Pyr_{12O1}TFSI$), c) N-N-diethyl-N-methyl-N-(2-methoxyethyl)ammonium bis(trifluoromethanesulfonyl)imide (DEMETFSI), d) *N*-butyl-*N*-methylpyrrolidinium bis(fluorosulfonyl)imide ($Pyr_{14}FSI$)

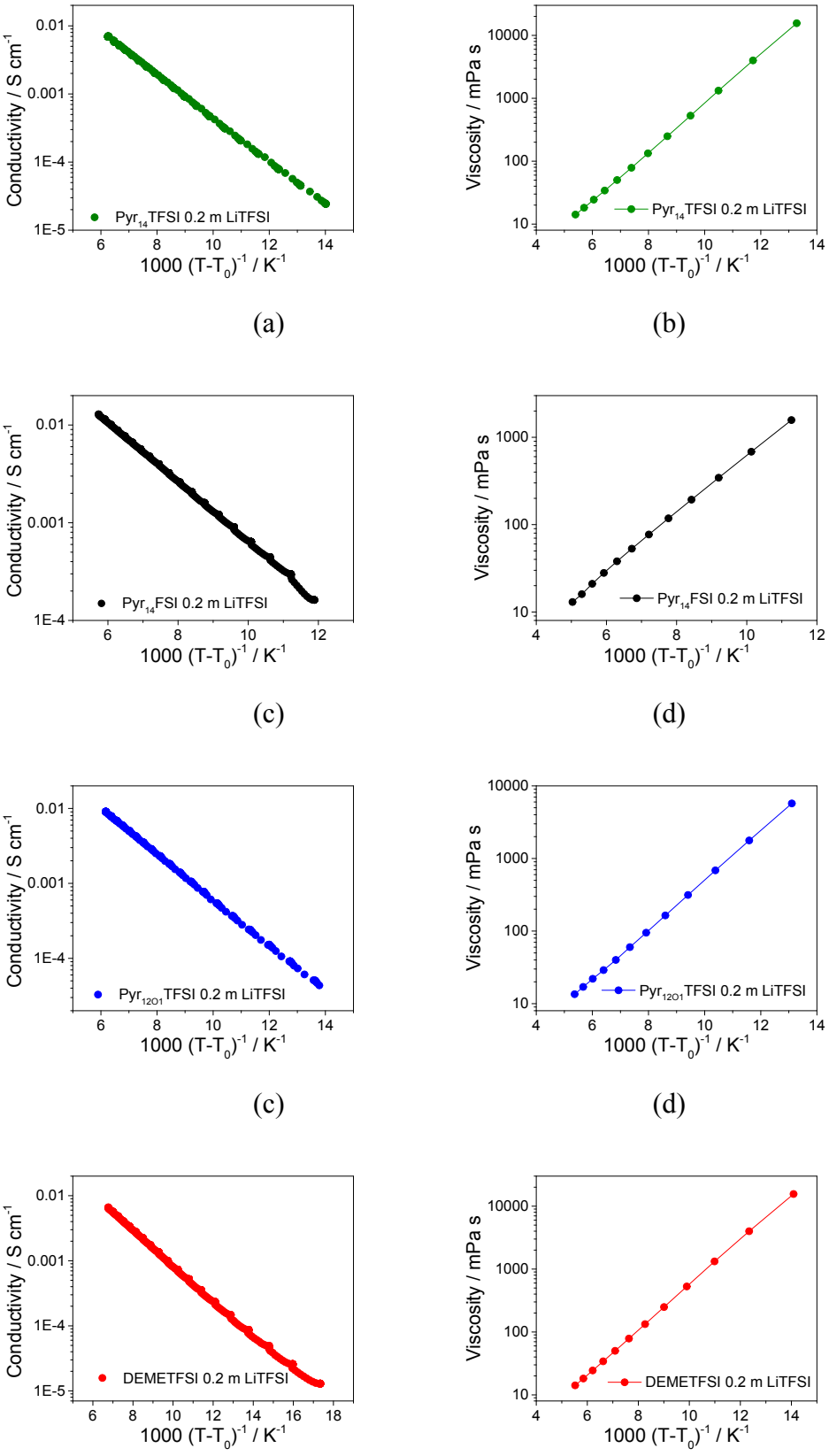
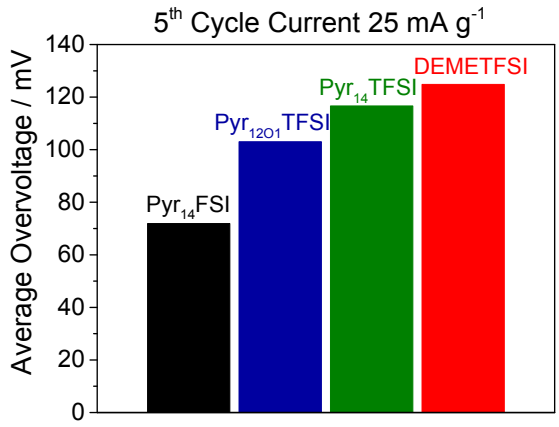
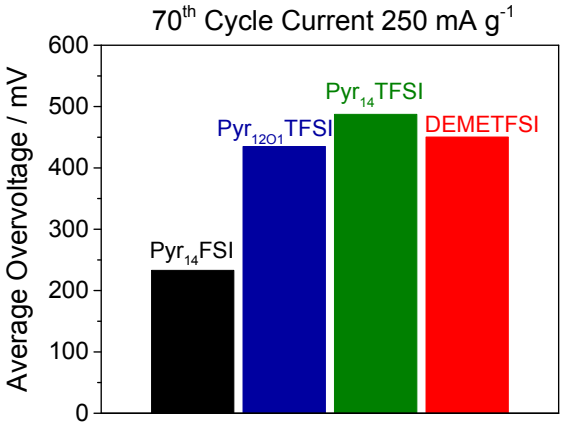


Figure S2 Conductivity and viscosity Vogel-Tammann-Fulcher (VTF) plots of $Pyr_{14}TFSI$-LiTFSI(a,b), $Pyr_{14}FSI$-LiTFSI (c,d), $Pyr_{12O1}TFSI$-LiTFSI (e,f) and DEMETFSI-LiTFSI (g,h).



(a)



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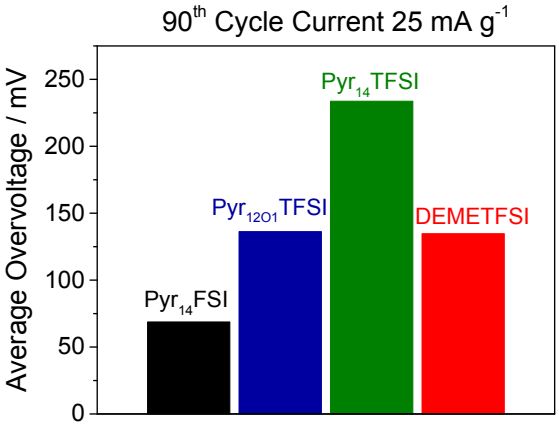
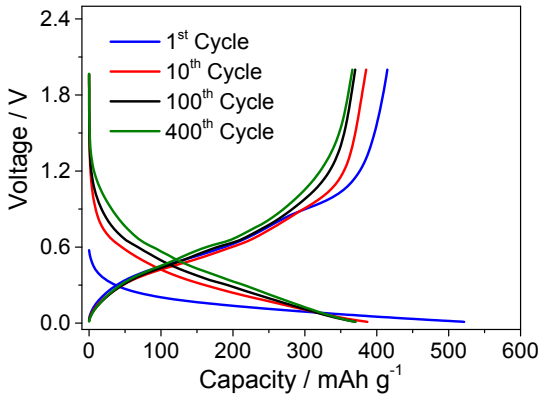
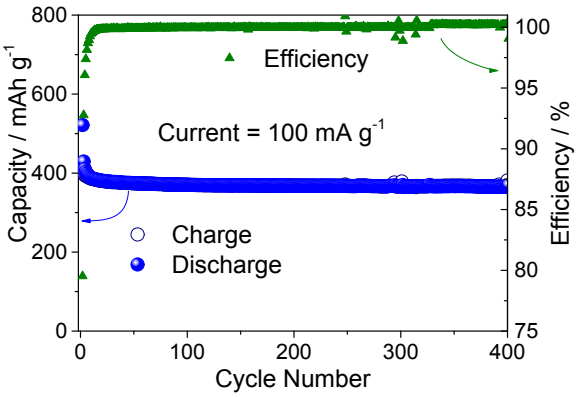


(c)

Figure S3 Average polarization during (a) the 5th cycle (measured at 25 mA g^{-1};0.12 mA cm^{-2}), (b) 70th cycle (measured at 250 mA g^{-1}; 1.2 mA cm^{-2}) and (c) 90th cycle (measured at 25 mA g^{-1}; 0.12 mA cm^{-2}) of the Li/IL/LFP cells employing the Pyr_{14}FSI-LiTFSI (black), the Pyr_{12O1}TFSI-LiTFSI (blue), the Pyr_{14}TFSI-LiTFSI (green) and the DEMETFSI-LiTFSI (red) electrolytes. Temperature 40 °C temperature. Voltage cut off 2.2-4 V.



(a)



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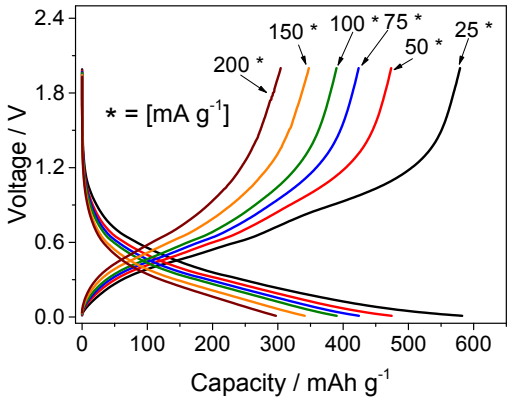

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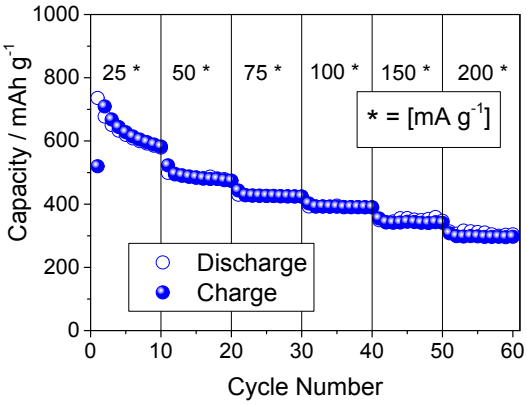
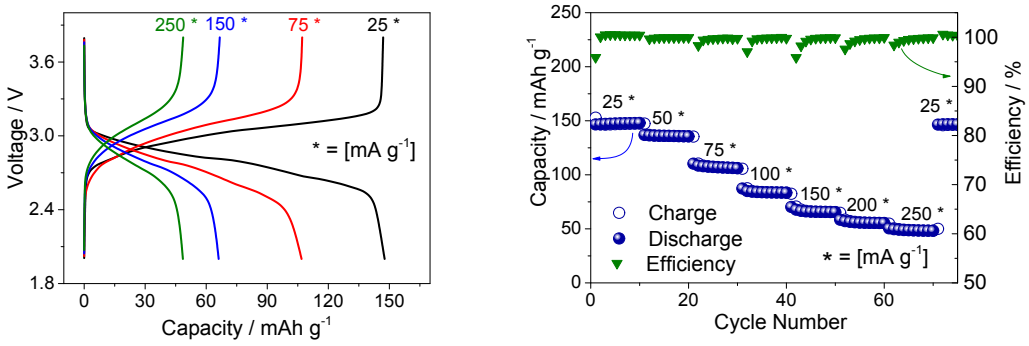


(d)

Figure S4 Voltage signatures **(a)** and cycling behavior **(b)** of the Li/Pyr_{14}FSI-LiTFSI/Sn-C cell upon galvanostatic cycle tests at 100 mA g^{-1} (0.25 mA cm^{-2}). Voltage signatures **(c)** and cycling behavior **(d)**, of the Li/Pyr_{14}FSI-LiTFSI/Sn-C cell upon cycle tests at increasing currents, i.e., 25, 50, 75, 100, 150 and 200 mA g^{-1} (0.065, 0.1875, 0.25, 0.375, 0.5 mA cm^{-2}, respectively). Temperature 40°C. Cut off voltages 0.01-2 V.



(a) *(b)*

Figure S5 (a) Selected voltage profiles and **(c)** cycling behavior (including columbic efficiency) of the Sn-C/Pyr_{14}FSI-LiTFSI/LFP full-cell galvanostatically cycled at increasing currents, i.e., 25, 50, 75, 100, 150, 200 and 250 mA g^{-1} (0.12, 0.24, 0.36, 0.48, 0.72, 0.96, 1.2 mA cm^{-2}, respectively) at 20 °C. Voltage cut off 2-3.8 V. The specific capacity (mA h g^{-1}) and specific current (mA g^{-1}) values are given with respect to the active mass of the LFP cathode.

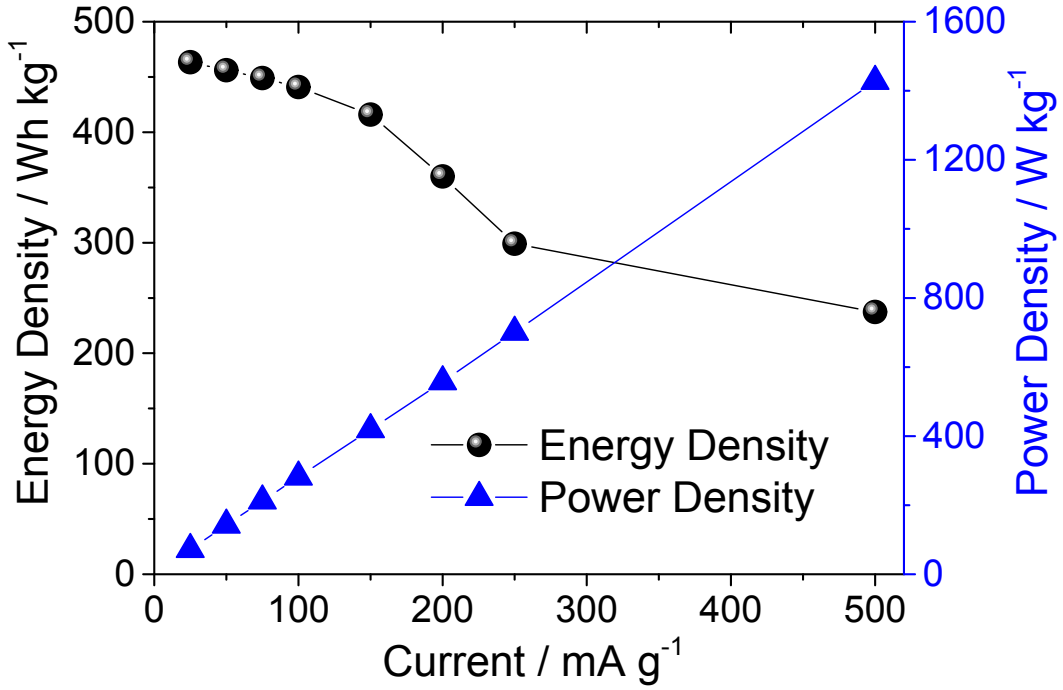


Figure S6 Energy and power densities of the Sn-C/Pyr_{14}FSI-LiTFSI/LFP lithium ion cell calculated basing on the data reported in Fig. 4 of the work. The values are given with respect to the active mass of the LFP cathode. Temperature 40 °C.

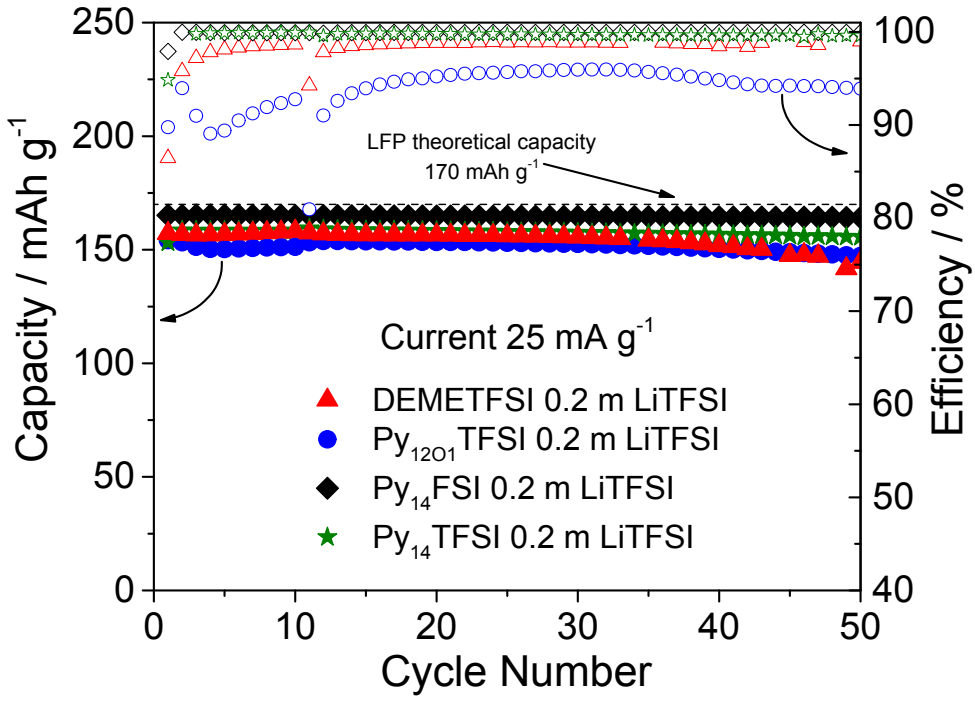
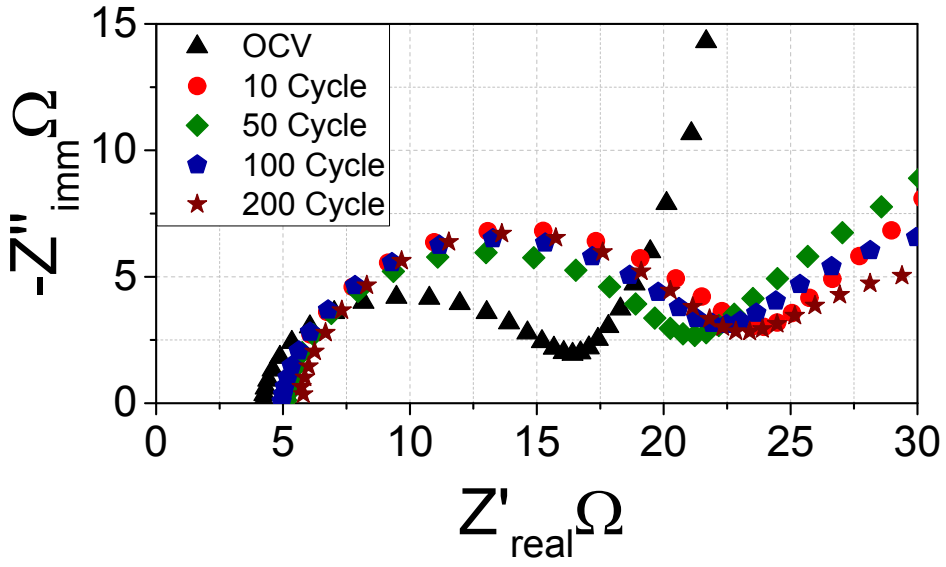
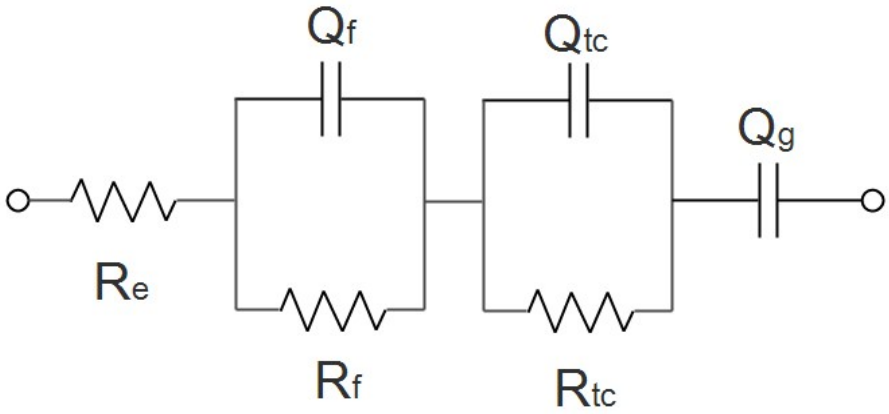


Figure S7 Cycling trend and columbic efficiency of the Sn-C/IL/LFP cells at 25 mA g^{-1} current (0.12 mA cm^{-2}). Voltage cut-off 2.2-4 V. Pyr_{14}TFSI-LiTFSI (green), Pyr_{14}FSI-LiTFSI (black), Pyr_{12O1}TFSI-LiTFSI (blue), DEMETFSI-LiTFSI (red). All measurements at 40°C. The capacity values are given with respect to the active mass of the LFP cathode.



(a)



(b)

Figure S8 a) Electrochemical impedance spectroscopy (EIS) Nyquist plots during cycling of the Sn-C/Pyr_{14}FSI-LiTFSI/LFP cell. Frequency range 1 MHz-10 mHz (10 mV signal amplitude), cycling test at 100 mA g^{-1} of current (referred to the LFP active mass). Voltage limits 2-3.8 V. Temperature 40 °C. b) $R_e(R_fQ_f)(R_{tc}Q_{tc})Q_g$ equivalent circuit, where R_e represents the resistance of the electrolyte, R_f and Q_f the resistance and the capacitance of the SEI film, R_{tc} and Q_{tc} the resistance and capacitance of the charge transfer process and Q_g the cell capacitance, respectively.