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Electronic Supplementary Information (ESI) of

Preparation and characterization of gel polymer electrolytes using poly(ionic liquids) and high lithium salt concentration ionic liquids

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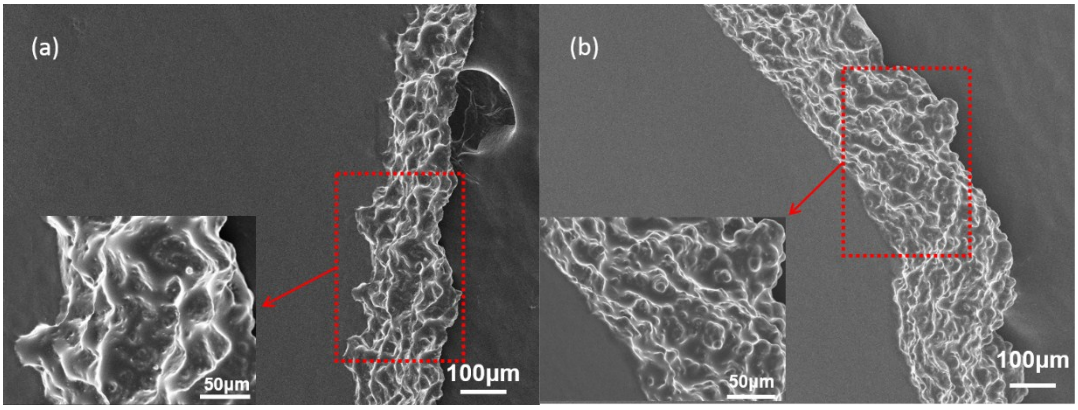

Figure S1. The SEM images of (a) GPE-40/60-Al_2O_3 and (b) GPE-50/50-Al_2O_3. The insets are the zoom-in images of highlighted cross-sectional areas.

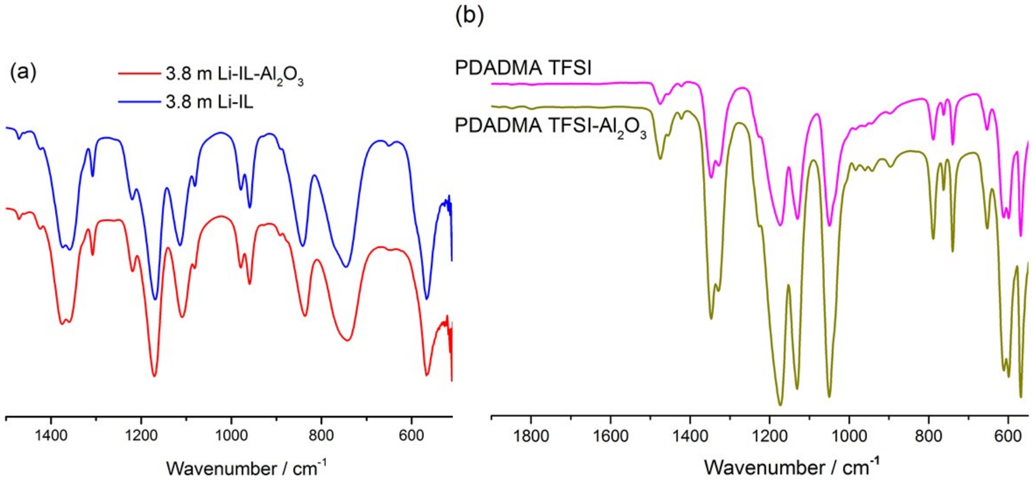

Figure S2. The comparison of FTIR spectra for (a) 3.8 m Li-IL samples with and without Al_2O_3 nano-particles; (b) PDADMA TFSI samples with and without Al_2O_3 nano-particles.

The mechanical properties is critically important for gel electrolytes especially in the applications of all-solid-state batteries. Thus, we selected the GPE-50/50-Al_2O_3 to investigate the mechanical behaviour by dynamic mechanical analysis (DMA). The DMA measurement was done under compression mode in N_2-filled environmental box, the H_2O level was less than 100 ppm. As shown in Figure S3, the storage elastic modulus (E') decreases with increasing of temperature which could result from the thermal relaxation of the polymer component. But it should be noted that the elastic modulus at 30 ^oC is relatively high, at 6.4 MPa.

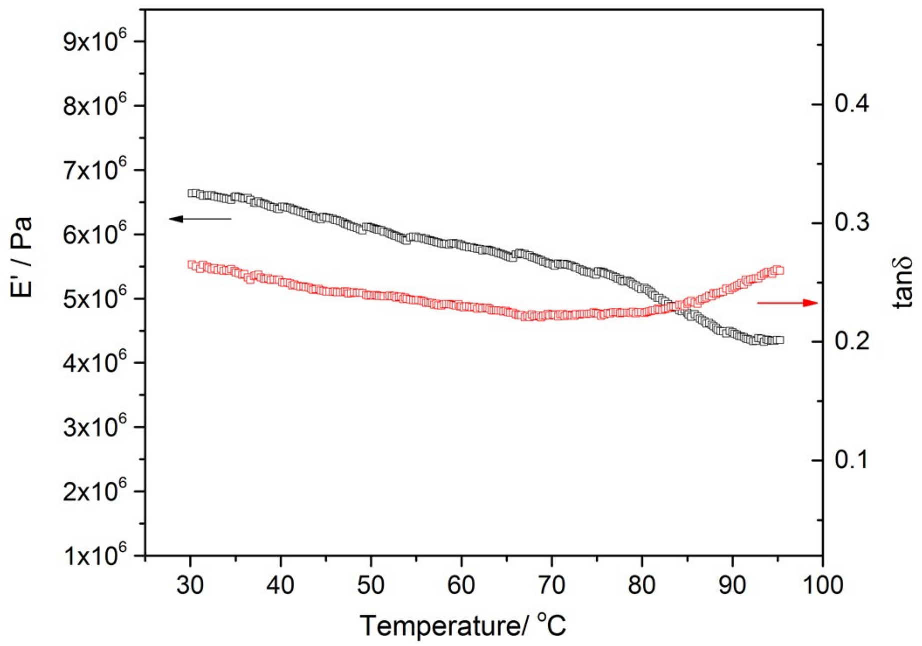

Figure S3. Temperature dependence of storage elastic modulus (E') and dissipation factor (tan δ) for GPE-40/60-Al_2O_3. The frequency is 1Hz and heating rate is 2 °C/min.

For the high voltage behaviour (up to +5 V vs. Li/Li^+) we measured linear sweep voltammograms (CV) from -0.5 to +5 V *vs.* Li/Li^+ for the promising GPEs (both GPE-50/50-Al_2O_3 and GPE-40/60-Al_2O_3 electrolytes) at a stainless steel (SS) working electrode with a potential sweep rate of 10 mV s^{-1} at 50 °C. Reversible Li plating/stripping was observed and higher current densities were reached in the case of the GPE-50/50-Al_2O_3. The results confirm a high voltage stability of the promising GPE.

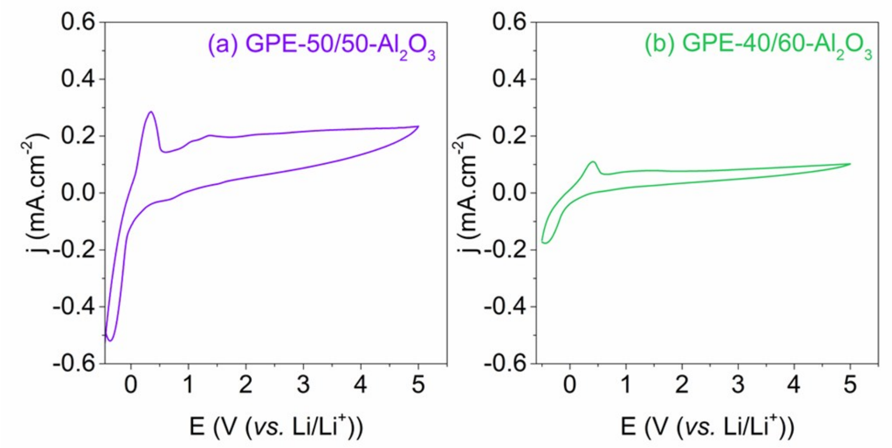

Figure S4. Linear sweep voltammograms (1st cycle) for GPEs with different composition (GPE-50/50-Al_2O_3 and GPE-40/60-Al_2O_3 electrolytes) at a stainless steel (SS) working electrode with a potential sweep rate of 10 mV s^{-1} at 50 °C.