Electrolyte is a critical component which is involved in balancing energy and safety specifications of batteries. Electrolyte solutions normally contain organic solvents that are required to be replaced with thermally stable materials to control their flammability. Ionic liquids (ILs) have been recognized as potential alternatives for this purpose. ILs are entirely composed of ions, and Coulombic interactions between ions add to a negligible vapor pressure to ILs. In the present study, the ILs containing bis(fluorosulfonylimide) (FSI) anions, which were selected due to their innate tendency to highly dissociate and in turn their high ionic conductivity, were designed as the electrolytes for lithium ion batteries.

1) Design of electrolytes Ionic conductivity is known to be suppressed below the melting point of electrolytes. Therefore, FSI anions were combined with a series of the cation which contains an ether oxygen to suppress crystallization. The IL, N-ethoxyethyl-N-methylpiperidinium bis(fluorosulfonylimide) ([P1,202][FSI]), was newly synthesized and mixed with LiFSI in ratio of 9:1: (IL:LiFSI mol/mol). The electrolyte mixture was confirmed to possess the low glass transition temperature of -88.8 °C without a crystallization feature.

2) Performance in a Li | LiFePO4 cell Figure (a) shows the cycling performance of the cell at C/10, which contains the [P1,202][FSI]-LiFSI as an electrolyte and LiFePO4 as a cathode. The cell retained the high capacity, which reaches the nominal capacity of LiFePO4 (150 mAh g⁻¹), with Coulombic efficiencies higher than 99 % from 3rd to 50th cycles. Also, a flat voltage profile essentially arose from LiFePO4 was preserved during the course of cycling.

3) Diffusion coefficient To understand the excellent performance of the cell, the Li | [P1,202][FSI]-LiFSI | LiFePO4 cell was analyzed by means of the cyclic voltammetry at different scan rates (Figure (b)). A diffusion coefficient was calculated by analyzing the plot based on Randles–Sevčik equation. A cell containing LP30 (1M LiPF6 in ethylene carbonate / dimethyl carbonate 1/1 v/v) was also analyzed as a control. The diffusion coefficient was calculated to be 1.4x10⁻⁷ and 9.6x10⁻⁸ cm² s⁻¹ for [P1,202][FSI]-LiFSI and LP30, respectively. Surprisingly, the higher diffusion coefficient was found for the IL-based electrolyte mixture. As a consequence of this, sufficient lithium stripping-plating was realized, and thus LiFePO4 exerted its intrinsic high performance by using [P1,202][FSI]-LiFSI mixture as the electrolyte.