Effect of Conducting Salts in Ionic Liquid based Electrolytes for Li-Ion-Batteries

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Ionic liquids are promising for applications in rechargeable lithium batteries because of safety and electrochemical stability issues. Therefore, new electrolyte formulations based on ionic liquids are investigated by researchers in detail, especially for high voltage applications. One of the most critical components in Li-ion batteries is the conducting salt with respect to a successful Li-ion transfer in the cell. The conducting salt, which is used up to date in most of all commercial Li-ion cells, is $LiPF_6$. However, $LiPF_6$ exhibits some characteristics that hamper it from being applied readily; for example, $LiPF_6$ decomposes at temperatures higher than 60 °C and exhibits a volatile reaction with water with the formation of highly toxic hydrogen fluoride (HF). Nevertheless, $LiPF_6$ is known as an excellent solid electrolyte interface (SEI) forming reagent and possess the most balanced properties at present. A promising alternative is lithium bis(trifluoromethyl-sulfonyl)azanide (LiTFSA), also known as lithium bis(trifluoromethylsulfonyl)imide (LiTFSI). It is stable up to several hundred degrees centigrade and decomposes to less toxic products. Besides, other lithium conducting salts also exhibit special characteristics which make them suitable for the use in Li-ion cells. It should be noted that the conducting salt cannot be considered in isolation. If the liquid electrolyte components are modified, the whole system including conducting salt and additives also has to be adopted.

In this study a systematic variation of the conducting salt, namely $LiBF_4$, $LiClO_4$, lithium trifluoromethanesulfonate (LiOTf), $LiPF_6$, and LiTFSA is presented in the electrolyte mixture of propylene carbonate (PC) and N,N-diethyl-N-methyl-N-(2-methoxyethyl)ammonium bis(trifluoromethylsulfonyl)azanide (DMMA-TFSA). By adding the organic carbonate PC to the ionic liquid DMMA-TFSA, the conductivity can be increased so that the lithium mobility (Li diffusion) is more and more favoured. However, the presence of PC results in an intercalation into the graphite layer. Therefore, two additives are applied in the electrolyte mixture, which are advantageous and necessary for a successful cell performance. The cell system is composed of a graphite electrode as anode and a NMC (= $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$) electrode as cathode, the measurements are performed in a Swagelok type cell design. A glass fibre disk, which is highly Li-ion permeable, is used as separator. It is shown that the cell performance is significantly affected by the choice of the conducting salt. On the one hand the use of certain conducting salts resulted in an unusable cell system.