A New Additive for Lithium Battery Electrolytes Based on an Alkyl Borate Compound and Its Effect on Improvement of the Elevated Temperature Cycling of Spinel $LiMn_2O_4$ Cathode

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Currently various studies have been done to develop electrolytes with high ionic conductivity, and good chemical and electrochemical stability for lithium batteries. In addition to the synthesis of new salts and solvents,[1,2] the use of anion receptors to reduce ion pairing in non-aqueous electrolytes has been extensively explored as a new approach by our group.[3-5] Anion receptors increase the conductivity of electrolytes and also increase the cation transference number in electrolyte. Therefore they are particularly useful for lithium batteries. Recently, we have reported on the synthesis of a new family of boron based anion receptors. We present here the electrochemical characterization of a new fluorinated alkyl borate compound tris(hexafluoroisopropyl) borate (HFPB). The fluorinated boron compound HFPB shows a dramatic effect on conductivity enhancement of lithium salts such as CF_3CO_2Li and LiBr, in EC-DMC solvents. The ambient temperature conductivity of these composite electrolytes was as high as ~5×10^{-3} S/cm. The electrochemical window for composite electrolytes containing HFPB is very high, 5.5 V for LiF salt and 5.23 V for CF_3CO_2Li salt. The composite electrolytes containing HFPB and CF_3CO_2Li salt were tested in $Li/LiMn_2O_4$ cell at room temperature and 55°C. This composite electrolyte is very stable with $LiMn_2O_4$ cathodes, the cell was cycled over 50 cycles with a coulomb efficiency as high as 98 to 100%. Capacity fading by the 50th cycle was only about 4 % (commercial $LiPF_6$ EC/DMC 1:1 electrolyte shows a 7 % capacity loss under the same conditions). Capacity maintenance in a $Li/LiMn_2O_4$ cell cycling at 55°C is much higher than that with commercial $LiPF_6$ electrolyte as shown in Figure 2. This preliminary result shows that, by eliminating of using $LiPF_6$ salt (which is responsible for the dissolution of manganese by acid attack) in electrolyte, the $LiMn_2O_4$ cathode displays better cycleability at elevated temperature with this composite electrolyte.

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References

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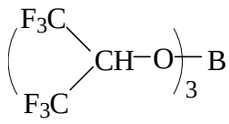

Figure 1 The chemical structure of tris(hexafluoroisopropyl) borate (HFPB) compound.

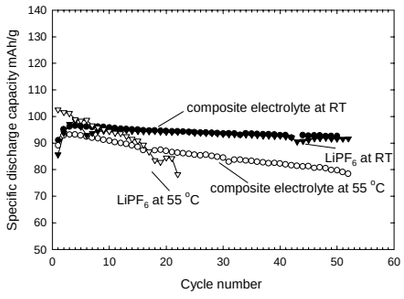

Figure 2 Discharge capacity vs cycle number of a $Li/LiMn_2O_4$ cell containing a composite electrolyte or a $LiPF_6$ commercial electrolyte cycling at room temperature and 55 °C between 3.5-4.5 V, C/3 rate.