

Additive Impacts on the Electrochemical Behavior of  
High Voltage Li-ion Batteries

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Future Li-ion batteries must be stable at higher potentials and higher temperatures than the ones currently available. Manganese dissolution from  $\text{LiMn}_2\text{O}_4$  (LMO) spinel cathodes is well known.<sup>1-3</sup> The high voltage spinel cathode,  $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$  (LNMO), has the potential for increased energy density, however, it suffers a similar problem of Mn dissolution as LMO spinel at elevated temperature.<sup>4-5</sup> The formation of a stable solid electrolyte interface (SEI) layer on both the cathode and anode may help to protect the electrolyte solution and the electrodes, leading to reduced capacity fading.

High voltage Li-ion batteries will also require modified electrolytes which do not continually decompose at the cathode surface during charging at voltages above 4.5V. A recently developed additive, tris(hexafluoro-isopropyl)phosphate (HFiP), has shown promising results in LNMO-containing Li-ion batteries.<sup>6</sup> HFiP will be examined alone and in combination with other additives

Our current research focuses on the LNMO spinel cathode and the effects of different additives and combinations of additives on the composition of the SEI formed. Electrochemical impedance spectroscopy (EIS) may provide insight to the reactivity at the cathode/electrolyte interface. EIS data for LNMO cathode half-cell configured coin cells as well as 3-electrode pouch cells using various different electrolyte/additive combinations will be reported. The EIS data correlated to the effects on capacity fading impacted by different additives will be presented.

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#### References

1. D. H. Jang, Y. J. Shin, S. M. Oh, *J. Electrochem. Soc.* **143**, 2204-2211 (1996).
2. A. Du Pasquier, A. Blyr, P. Courjal, D. Larcher, G. Amatucci, B. Gerand and J-M. Tarascon, *J. Electrochem. Soc.* **146**, 428-436 (1999).
3. E. Wang, D. Ofer, W. Bowden, N. Iltchev, R. Moses and K. Brandt, *J. Electrochem. Soc.* **147**, 4023-4028 (2000).
4. W. Choi and A. Manthiram, *J. Electrochem. Soc.* **153**, A1760-A1764 (2006).
5. D. W. Shin, C. A. Bridges, A. Huq, M. P. Paranthaman, A. Manthiram, *Chem. Mater.* **24**, 3720-3731 (2012).
6. A. v. Cresce and K. Xu, *J. Electrochem. Soc.* **158**, A337-A342 (2011).