Applications of Stabilized Lithium Metal Powder (SLMP) in Lithium-ion Batteries

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With increasing demanding of energy, it becomes more and more important to find alternative energy sources beyond fossil fuels, and application of batteries, especially lithium ion batteries (LIB), has been extended to large scale energy storage due to their unique advantages of high energy densities (up to 150 $Whkg^{-1}$). To meet the requirement for applications in electric vehicle (EV) and hybrid electric vehicle (HEV), it is desirable to develop high energy density and low cost materials. With current Li-ion technology, lithium in the cell is limited from cathode material, e.g., $LiCoO_2$ etc., and electrolyte. Solid-Electrolyte Interphase (SEI) formation during initial cycles consumes lithium and results partial capacity loss irreversibly. The incorporation of stabilized lithium metal powder (SLMP), developed by FMC corporation, into anode has been suggested to overcome the irreversible capacity loss, and increase the capacity by 5~10%. Moreover, some non-lithiated materials with high specific capacities can be used as cathode materials if coupled with pre-lithiated anodes. With this strategy, the full cell energy density can be significantly improved.

In this report, we demonstrate the application of SLMP in anode materials. To apply SLMP into the anode electrodes, two strategies have been applied: SLMP was either added into electrode slurry for film casting, or sprayed directly on top of anode laminate. The former method has been demonstrated previously. [1,2] In this study, we focus on the latter method. Cells assembled with prelithiated anodes were allowed to rest for various days before cycling. Without any low C-rate formation process, the cycling results suggest that the anode prelithiation can help the development of SEI.

In this study, CGP-G8 graphite from Conoco Phillips was mixed with polyvinylidene fluoride (PVDF), acetylene black (AB) in NMP to make slurry with the weight ratio of: 82% CGP-G8, 15% PVDF, and 3% AB. After dried in vacuum oven at 130°C for 16 hours, SLMP powders were loaded on top of the anode electrode by spray method. The SLMP was activated by calendering. Coin cell assembly was prepared in standard 2325 coin cell hardware in argon filled glove box. As shown in Figure 1, with the incorporation of SLMP, the open circuit potential of graphite/Li half cell dropped quickly to 0.1 V, indicating the partial lithiation of graphite. Half cell performance for SLMP-lithiated graphite anodes with different resting time has been tested. The results indicate that the cell without resting has significant capacity drop during the first several cycles, while with a resting time of two days or longer, cell capacity of the first cycle increases by up to 10%, and can be stably maintained. This very likely reveals the full development of SEI on SLMP-lithiated graphite with long enough resting time. Development of such SEI (using SLMP method) is equivalent to the slow formation protocols used in regular lithium ion cells. The impact of different amount of SLMP added in anode is studied for both half cell and full cell and the results will also be reported.

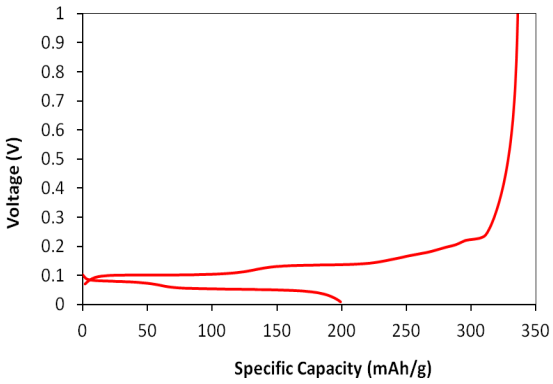

Figure 1. First cycle voltage profile of the graphite/Li half cell. A 5wt% SLMP (ratio of lithium over graphite content) was added on the anode electrode. The cell was rested under open circuit for two days before cycling.

References

1. Z. Wang, L. Wang, V. Battaglia, L. Gao, 2013 MRS Spring meeting, San Francisco, USA, April 1-5, 2003
2. C.R. Jarvis, M.J. Lain, M.V. Yakovleva, Y. Gao, J. Power Sources, 162, 800 (2006).