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Performance of Sandia-Built Li/$(CF_x)_n$ Cells

Ganesan Nagasubramanian, Kyle Fenton
2546 Advanced Power Sources R & D Department
Sandia National Laboratories
Albuquerque, NM 87185
Ph: 505-844-1684
Fax: 505-844-6972
Email: gnagasu@sandia.gov

Introduction:

Recently, there is renewed interest in the use of Li-CF_x battery by the US military for the ground based warfighter and at Sandia for internal use. This renewed interest in the primary chemistry is mainly due to combination of two factors: 1) The specific capacity of this chemistry is higher (860mAhr/g) than rechargeable chemistries (~150mAhr/g/charge) and 2) recharging batteries is often not an option or not desired.

In an effort to support internally funded research projects we launched a program aimed at developing optimized Li/CF_x electrodes and cells. Leveraging our in-house cell building and prototyping capabilities, we were able to evaluate different formulations of cathode materials and different material handling processes to optimize performance. The typical electrode composition for Sandia coated CF_x cathode is: CF_x (90 wt%); PVDF (5 wt%); and acetylene black (5 wt%). Details on the coating process using our in-house prototyping capability have been published elsewhere[1]. Figure 1 shows a prepped CF_x electrode for 18650-cell, a matching Cu-cladded Li electrode is shown in Figure 2, and a finished 18650-cell is shown in Figure 3.

Electrochemical Performance:

Figure 1 - SNL coated $(CF_x)_n$ electrode with tab welded ultrasonically.

Figure 2 - Li electrode with Cu cladding.

Figure 3 - SNL Built 18650 CFx cell.

We increased delivered capacity of Sandia built 18650-cell from 1.5Ahrs to 3.6Ahrs as shown in Figure 4 for $CF_{x=1}$ cathode. This was accomplished by optimizing the methodologies for slurry making such as electrode formulation and coating parameters.

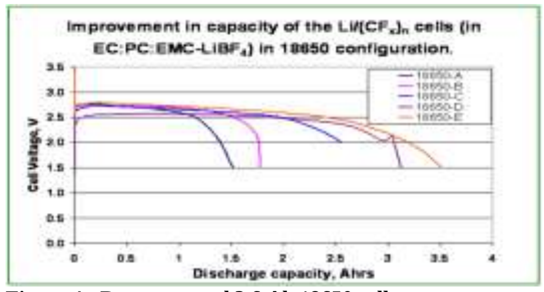

Figure 4 - Demonstrated 3.6 Ah 18650 cell.

Temperature Performance:

We also tested $(CF_x)_n$ cathodes (x=1.0 and 0.9) in 18650 cells for pulse performance while cycling oven temperature between -40 and 72 °C. The temperature profile consisted of 12 distinct temperature steps, with room temperature being the beginning and end step. At each temperature the oven stayed for 4 hrs before moving to the next, with the entire cycle taking 48 hrs total. The pulse duration was kept very short (4 ms pulse every 10 s) and the total capacity removed during each temperature cycle (48 hours) was ~ 364 µAhr. In order to determine the capacity at which the cell fails (reaches the cut-off voltage), after each full temperature cycle, the battery was drained a percentage of the overall capacity using a constant current discharge, followed by the subsequent pulse discharge and temperature cycle. This procedure was repeated until the cells hit the 1.5V cut-off voltage.

Figure 5 shows the voltage response for the last pulse cycle when the cell failed for x=0.9. Both cells failed at -40°C. After failure, the remaining capacity was drained at 25°C which is shown in the figure. Also in the figure is shown the cumulative capacity value drained up to the last pulse cycle. The cell failed after removing ~2 Ahrs and the remaining capacity is only 0.02 Ahrs. Similar observation was made for x=1. However, this cell failed sooner (after removing only1.8Ahrs) with a remaining capacity of 600mAhrs. Remember the cell with x=0.9 has

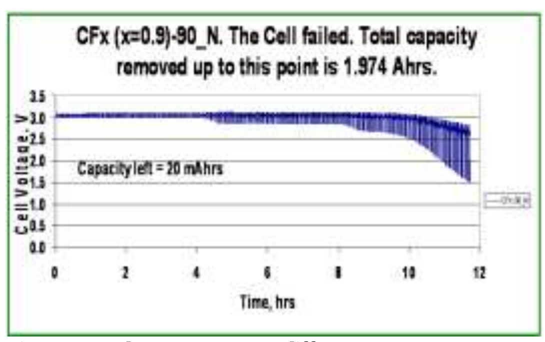

Figure 5 - Voltage response at different temperatures.

lower cell capacity than for the cell with x=1. Despite the lower capacity this cell performed better than the other. Our data show that the cell with x=1 only delivered ~ 75% of the total capacity while the x=0.9 gave ~ 99% of the total capacity before failing.

Acknowledgment:

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References:

1. G. Nagasubramanian, Int. J. Electrochem. Sci. 2, 913 (2007).