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Electrochemical characterization of CF_x material for an internally funded project

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Introduction:

Recent classification of SO_2 and $SOCl_2$ (these are catholytes in primary Li batteries) as a health hazard[1] led to a surge of interest in CF_x as a potential replacement for these chemistries. The CF_x has several positive attributes including very low self-discharge and high specific capacity (865mAhr/g), but low discharge constraints remain a challenge. As the application portfolio expands to accommodate Military, Space etc. the performance requirements also increases to include wide temperature operation, high discharge capability etc. As the battery operation extends to high temperature thermal runaway also becomes a key concern and must be mitigated or possibly eliminated for a wide-spread adoption of this chemistry.

At Sandia National Labs we have the necessary in-house capability (battery prototyping, thermal abuse and materials syntheses) to address the limitations and concerns described above. We started an internally funded program to investigate CF_x materials from different suppliers for electrochemical and thermal performances. We will down select the best candidate material for further optimization in large capacity cells (18650 and pouch).

For this program we purchased CF_x powder materials of two different compositions (x=1; 0.9) from 3 different vendors designated as CF_x-1, CF_x-2 and CF_x-3. The typical electrode composition for Sandia coated CF_x cathode is: CF_x (90 wt.%); PVDF (5 wt.%); and Denka carbon (5 wt.%). Details on the coating process using our in-house prototyping capability have been published elsewhere[2]. Electrodes will be evaluated in 2032 coin cells. These cells will be tested for relevant electrochemical properties including rate, performance at temperatures etc. in EC:EMC(3:7 w%)-1MLiPF_6. All data presented here are for x=0.9.

EC: Ethylene Carbonate; EMC: Ethyl Methyl Carbonate.

Electrochemical Performance:

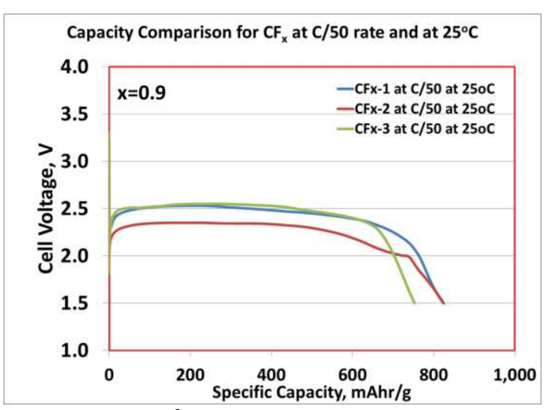

Figure 1- Specific Capacity comparison at a C/50 rate for materials from 3 vendors

Figure 1 compares the specific discharge capacity for the CF_x material from the three suppliers. While CF_x-1 and CF_x-3 show comparable cell voltage, CF_x-2 shows chronically lower discharge voltage but exhibits a similar specific capacity to CF_x-1. Data for C/100 and C/200 discharge will be discussed at the meeting.

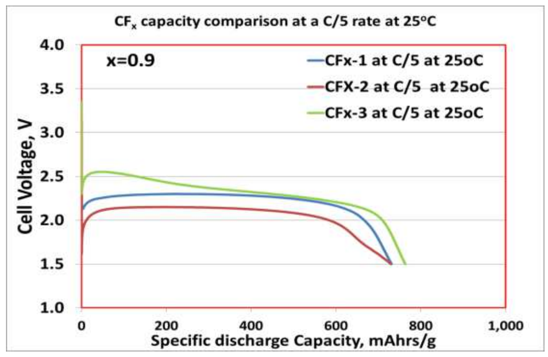

Figure 2- CF_x capacity comparison at a C/5 rate

Again CF_x-2 shows lower cell voltage compared to the CF_x-1 and CF_x-3. The data clearly show that the materials at this high rate (C/5) delivered marginally less specific capacity (<800 mAhrs/g) only compared to C/50 rate. However, the decrease in capacity at high rate is not significant.

Temperature Performance:

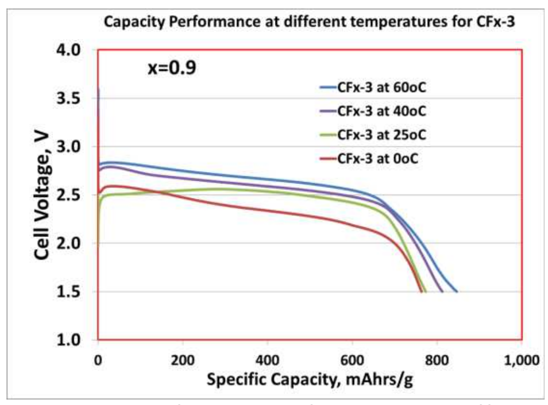

Figure 3- Performance of CF_x-3 at different temperatures

The cells were tested at four different temperatures. The expected trend in voltage ($60^oC>40^oC>25^oC>0^oC$) was observed with temperature. The cells delivered over 800mAh/g at 60 and 40^oC and under 800mAhr/g for 25 and 0^oC. Impedance data at different SOCs and temperatures will be presented at the meeting.

Acknowledgment:

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References:

1. http://www.atsdr.cdc.gov/tfacts116.pdf
2. G. Nagasubramanian, Int. J. Electrochem. Sci. 2, 913 (2007).