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Storage Characteristics of Li-Ion Batteries for NASA's Missions

B. V. Ratnakumar, M. C. Smart, K. B. Chin, L. D. Whitcanack, and S.R.Narayanan and S. Surampudi
Jet Propulsion Laboratory,
California Institute of Technology
4800 Oak Grove Drive, Pasadena, CA 91109

INTRODUCTION

NASA's planetary exploration missions are aimed at understanding the geological and environmental conditions, and at determining the existence of water, as a precursor to life, on different planets and their moons in our solar system. There is a continued interest to examine the neighboring as well as distant planets and planetary objects, a evident from the upcoming missions including: "Return to Moon", "Missions to moon, Mars and Beyond", and "Jupiter Ice Moon Tour Orbiter (JIMO)".

One challenging aspect common to these missions is a long calendar life, of about ten years or longer, for batteries. Traditionally, nickel-cadmium and nickel-hydrogen systems were opted for such long-life missions. Of late, lithium-ion chemistry, which made a significant impact on the commercial portable electronics devices, is being examined as an alternative, to take advantage of its high specific energy and energy density. However, this chemistry, being relatively new and still evolving, lacks in real-time storage data on long calendar life. Thus far, only a few studies are available on the storage/shelf life characteristics of lithium-ion cells/batteries.[1-4] The objective of this study is, therefore, to assess the storage characteristics of aerospace prototype lithium-ion cells.

The studies reported here involve 7 Ah prismatic cells from Yarndey Technical Products (or Lithion) from Pawcatuck, CT, and 9 Ah cylindrical DD cells from SAFT America, Inc., Cockesville, MD. These cells have been on storage for the last four years, at a floating charge voltage of 3.65 V corresponding to ~50% state of charge, and at five different temperatures, i.e., 55^{o}C, 40^{o}C, 23^{o}C, 10^{o}C, 0^{o}C, and -20^{o}C. These cells have been subjected to capacity checks, both at ambient and low temperatures, as well as AC impedance (EIS) measurements, after each three months of storage. Additionally, three cells were stored uninterrupted, without capacity or impedance checks, at 10^{o}C, 0^{o}C, and -20^{o}C for the last three years. In this paper, we will provide updates of the capacity retention and electrochemical impedance characteristics of all these cells as a function of storage duration.

The storage characteristics exhibited thus far by both prototype cells are quite impressive. Over 95% of capacity is retained after three years of storage at sub-zero temperatures (Fig.1). The capacity fade is higher at high storage temperatures and follows Arrhenius–type behavior for both types of cells. The projected calendar lives of these cells are quite promising and point to the applicability of Li-ion technology in extended-life missions The detailed storage data generated from our studies will be examined in the context of two models, i.e., with a growth of the solid electrolyte interphase (SEI) on the carbon anode[3] and with the loss of electronic conductivity on the cathode,[4] due to morphological arrangements prompted by the volume changes upon intercalation/deintercalation.

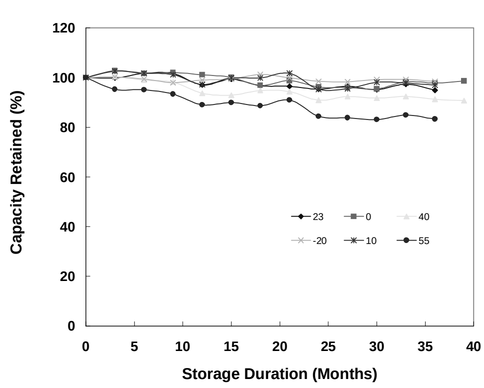

Fig. 1: Capacity of Li ion cell during storage.

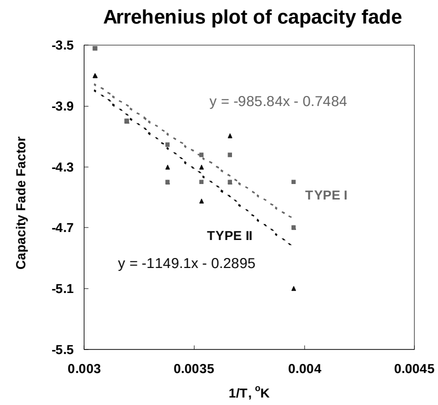

Fig. 2 Capacity fade of Li-ion cells on storage.

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REFERENCES

1) B.V Ratnakumar, M. C. Smart, and S. Surampudi, "Storage Characteristics of Lithium-Ion Cells" Proc. Symp. Li Batteries, ECS 196th Electrochem. Soc. Meet., Honolulu, Hawaii, Oct., 1999.
2) K. B. Chin, M. C. Smart, B. V. Ratnakumar, L. D. Whitcanack, E. D. Davies, M. D. Rodriguez, F. Deligiannis, and S. Surampudi, ECS Fall Meeting, Salt Lake City, UT, Oct. 2002.
3) M. Broussely, S. Herreyre, P. Biensan, P. Kasztejna, K. Nechev, and R. J. Staniewicz, *J. Power Sources*, **97-98**, 13 (2001).
4) T. Inoue, H. Yoshida, M. Mizutani, and M. Goto, "Qualification Test Results of 100 AH Lithium Ion Cells for Space Applications", 18th AIAA International Communications Satellite Systems Conference, Oakland, CA, Apr. 10-14, 2000. Takefumi Inoue et al, NASA Battery Workshop, Huntsville, AL, Nov., 2001.