Li-Ion Cells for Terrestrial Robots

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INTRODUCTION
Lithium ion batteries offer significant advantages, in terms of mass of volume, compared to the conventional Ni-Cd and Ni-H2. Accordingly, numerous efforts are underway to develop appropriate Li ion batteries, to evaluate various performance characteristics such as cycle life, calendar life, extreme temperature performance (-20°C > T > 30°C) etc., and to demonstrate the readiness of these technologies for a variety of NASA’s robotic planetary exploration missions, including planetary rovers, landers and orbiters. At JPL, the transition to Li ion batteries for landers and rovers was facilitated by the development of low temperature batteries, primarily via a modification of the electrolyte solvent, to achieve low viscosity and high ionic conductivity at low temperatures, combined with good film-forming capability to provide the desired electrochemical stability. Li ion batteries, utilizing this electrolyte mixture, were qualified for the 2001 Mars Lander mission, which was later cancelled, as well as on the current Mars Exploration Rover mission. Other research efforts at JPL also resulted in quaternary mixture electrolytes with enhanced performance at low temperatures down to -40°C. Li ion cells containing these electrolytes exhibited resilience at ambient and moderately warm temperatures, up to 40°C, as well as at low temperatures. 

Apart from the robots for planetary exploration, JPL is also interested in robots for terrestrial applications as well. The environments for such applications are equally challenging, with operating temperature as high as 55°C. In addition, these unmanned vehicles are highly maneuverable as well as portable, and, therefore, require high specific energy batteries. The state of art battery system is Ni-Cd, which has considerable penalty on mass and volume, not to mention the high self-discharge at high operating temperatures. At these high operating temperatures for Li ion cells, there would be problems associated with the instability of salt LiPF6, solubility of cathodes and enhanced oxidation of electrolyte.

In an effort to qualify Li ion technology for military mobile robotics and other terrestrial robotic applications, we have undertaken a detailed evaluation of wound-prismatic, 5 Ah MP series cells obtained from SAFT. The study involves a routine performance characterization at different charge and discharge rates at different temperatures, followed by cycling to 100% depth of discharge, at various temperatures of 23, 40, and 55°C. The capacity fade was monitored at discharge rates of C/10, C/5, C/2.5, and C, after each 100 cycles. Furthermore, in order to understand the capacity fade, EIS measurements were also performed after each 100 cycles as a function of states of charge. The preliminary results of this study are promising and establish the feasibility of Li-ion technology for terrestrial robots requiring good cycle life at elevated temperatures.

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REFERENCES