LOW TEMPERATURE PERFORMANCE of Li/S BATTERIES

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This paper discusses development of a new generation of Li/S rechargeable batteries with energy density exceeding **180 Wh/kg** and rate capability comparable to aqueous systems. Cells with nominal capacity 700 mAh, weight 9.8 g and dimensions 50 x 36 x 7 mm were cycled at -20 ^{o}C and showed **85%** of retained capacity at C/2 discharge rate compared with room temperature. The cells demonstrate **5C** discharge rate at **-40 ^{o}C**. Retained energy and capacity at -40 ^{o}C exceeded 60 % and 80 % respectively. At room temperature cells generate specific power up to 750 W/kg. Cells are inherently protected from overcharge at low and room temperatures by internal chemistry and can sustain 30 times overcharge at C/2. It was shown that at -40 ^{o}C sulfur cathode discharge includes at least five steps. There are two steps known at room temperature. Thermal effects related to different charge discharge regimes were analyzed. It was shown that cell polarization consists of Ohmic and Arrhenius portions connected in series. The Arrhenius portion with activation energy ~0.25 eV dominates at temperatures below –20 ^{o}C. At room and elevated temperatures the electrochemical processes became so fast that total cell polarization was limited by contacts to aluminized PET cathode substrates, spray metal contacts and electrode tabs.

The Li/S system with its liquid cathode has fundamental advantages. Li-ion intercalated cathode and anode are kinetically limited by solid phase diffusion, which are several orders of magnitude lower compared to liquid diffusion. At low temperatures advantages of the liquid cathode system are even more distinct because of lower activation energy resulting in lower temperature sensitivity of rate capability. Li/S systems operating with liquid polysulfide cathodes are free from solid phase diffusion limits and their rate capability behavior and low temperature performance are more similar to $Li/SOCl_2$ and Li/SO_2 systems.

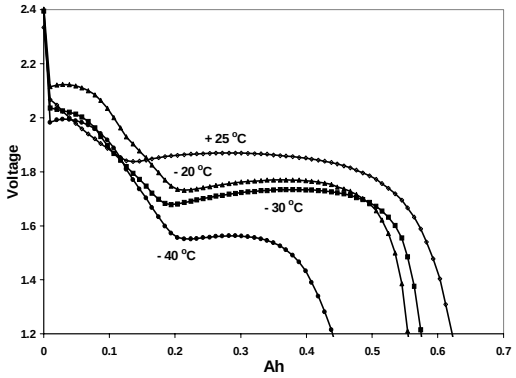

Fig.1. Discharge profiles at different temperatures. Discharge 3.5 A (5C).

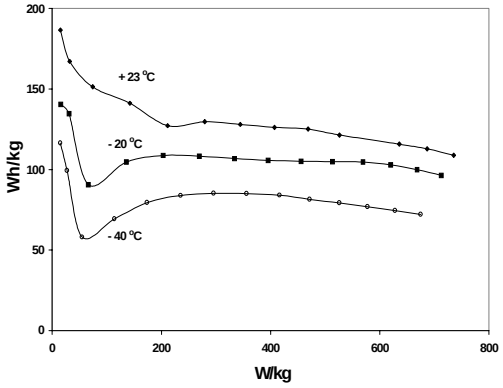

Fig.2. Experimental Ragone plots at different temperatures

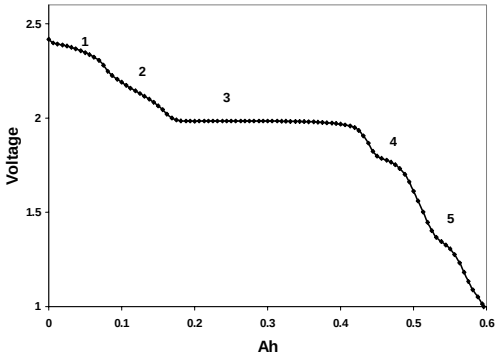

Fig.3. Discharge 70 mA at –40 ^{o}C.