Calorimetric studies of the thermal behavior of Li-ion coin cells: calibration and measurement with a Tian-Calvet calorimeter

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In order to understand the heat generation in Li-ion cells during operation, the investigation of thermal properties is essential. This work contributes a novel approach to study the specific heat capacity of Li-ion coin cells as well as its heat effect during cycling. In this study a Tian-Calvet calorimeter (C80, Setaram) with a resolution down to 0.1 µW was used to measure the temperature change and heat flow in small coin cells during charging and discharging. The tested coin cells with a nominal capacity of 85 mAh had a diameter of 14 mm and a height of 5.4 mm, which fits in the sample tube of the C80 calorimeter. Temperature calibration was performed in the temperature range of 25-160 °C using three different reference materials: gallium, potassium nitrate, and indium. Each material was heated up under three different scanning rates, which were 0.1, 0.3, and 0.5 K/min for In and KNO_3; 0.01, 0.05, and 0.1 K/min for Ga. The temperature correction values were obtained with an average value of 0.16 °C. The heat capacity of the Li-ion cells were determined by using α-Al_2O_3 (SRM 720, NIST) as reference material. In the temperature range of 25-60 °C, the specific heat capacity measurements were carried out using continuous and discontinuous methods. The results of both methods showed a good agreement. In addition, the coin cells were charged and discharged under constant current conditions of 42.5 mA (0.5 C), 85 mA (1C), and 170 mA (2C). During cycling in the C80 calorimeter, the heat generation was simultaneously recorded via heat flow signals. The measurements were repeated on three cells and the results showed a good agreement within the experimental uncertainty. The heat flow calibration was performed using an aluminum-housed resistance heater (Arcol, England). The results of this study provide quantitative results of the heat generation and dissipation of Li-ion cells during operation.