1. Introduction

The main application of the isothermal battery calorimeter is accurate and easy testing of heat output from charging and discharging a single battery. Lithium-ion covers a range of battery chemistries which involve the flow of lithium ions from the anode to the cathode. Lithium-ion is typically a secondary cell technology, meaning that the lithium-ion batteries are rechargeable.

Heat changes occur during the charging and discharging of batteries is mainly due to their internal impedance. Energy lost as heat cannot be used as useful electrical energy so it is important to minimize the heat produced by cells during use. Companies utilizing batteries need to quantify this heat so adequate cooling can be added if required.

The IBC allows custom charge/discharge cycles to be carried out with ease using the in-built cycler in combination with the control software. The calorimeter is isothermal and heat is removed or added to the cell using a Peltier heater. This works by using power compensation to keep the temperature inside the chamber constant. Heat flow to and from the Peltier is recorded with the software and can be used to give information about battery performance and parameters.

2. Experiment

The cell is loaded into the metal chamber inside the IBC. This chamber is in contact with the cell casing i.e. the negative terminal. The IBC lid connector touches the positive terminal of the cell when closed and completes the connection, allowing current to flow to and from the cell.

Custom charge and discharge tests can be carried out on the cell using the “Battery Analyser” software. Cell performance is compared by running identical charging and discharging regimes on different cells. Cells of different chemistries, different ages or different capacities can be compared using these tests. Tests may also be carried out under different temperatures in order to evaluate cell performance in extreme thermal conditions; from -5°C to 80°C.

All experiments detailed here were carried out in the THT Isothermal Battery Calorimeter. The IBC is engineered to hold a particular size of battery. The IBC used here is designed for testing of 18650 cells. Two different types of 18650 cell are tested in order to provide comparative data. The properties of the two cells are as follows:

“Cell 1” high capacity (2400 mAh) 18650 lithium-ion cell

“Cell 2” low capacity (1100 mAh) 18650 lithium-ion cell

A charge/discharge regime with the following parameter was used:

- Constant current charge at 1100mA to 4.1V, this is C/2.2 for cell 1 and C for cell 2
- Constant voltage charge at 4.1V to 55mA
- Constant current discharge at 550mA to 2.8V, this is C/4.4 for cell 1 and C/2 for cell 2
- Constant voltage discharge at 2.8V to 55mA
- This cycle is repeated two further times.

The user should ensure that the test parameters fall within the batteries operational parameters. The IBC is not designed to withstand the exothermic decomposition of a lithium-ion cell. These comparative tests are useful not only for comparing types of cells, but also for comparing cells of different ages, cells that have been subjected to different operating temperatures, cells that have been used under different discharging regimes etc.

The sensitivity of the instrument allows it detect very small variation in the cell’s electrical and thermal behaviour arising from minor differences in how the cell has been treated.
4. Conclusions

In general very reproducible heat patterns over the repeating charge/discharging cycle are observed. Each cell has a characteristic “shape” of heat output graph for both its charging period and its discharging period.

Most of the heat production occurs during the constant current charging period. During constant voltage charging, the current level drops rapidly and the heat output drops in tandem with the current. This pattern is repeated in the discharge period of both cells.

Because the IBC’s current and voltage patterns are very repeatable, it would be easy to use the IBC to age batteries by running them on charging/discharging cycles over a period of weeks or months. The changing of a battery’s thermal and electrical behaviour with age is an important property to characterize, and the IBC is perfectly suited for this kind of work.

3. Results

Variation between the two cells is apparent from the electrical and thermal data above. The low capacity cell finishes the three cycles in less than half the time of the high capacity cell, as expected.

The change in voltage in the charge and discharge period is significantly different in the two cells. Cell 1 has very short periods of constant current charging followed by long periods of constant voltage charging. Cell 2 has much shorter constant voltage periods during the charging phase, but has longer constant current charging periods prior to this.